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*The Journal of*

THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE

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VOL. 12, Nos. 1-2 JUNE, 1946

# Some thoughts about Agriculture*

By

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When it was suggested that the occasion of the general meeting of the Institute should also be the occasion for a presidential address, it seemed appropriate, as the war was ended, to engage in a review and to bring into focus some of the problems facing us now. There will not be anything new in it, no suggestion, for example, that nuclear research will come to the aid of the farmer by way of modifying climate, but it is hoped that thought may be further stimulated to some degree about our agricultural position.

Ages ago, man began to till the soil that he might produce more food, and you will notice throughout this talk that the production of food is a continuing theme. On another occasion, it may be possible to consider production other than food. Over long periods, centuries indeed, land was laboriously cleared and subjected to tillage of a simple sort, and production was decidedly local, as was also consumption, and undoubtedly more people were under-nourished, if not famine-stricken, than well-fed.

With the use of clover and turnips, the development of rotations, use of farm-yard manure, and improvement of livestock which became evident in the 18th century, food production was greatly increased, thereby providing the means of subsistence for an increasing population in Europe. The agrarian advance was succeeded by revolutionary achievements in mechanization of farm implements, such as the reaper and binder developed in Scotland by Patrick Bell while in his 20's, and by Cyrus McCormick in U.S.A., also a young man in his 20's. The full effect of the industrial revolution was by now becoming evident, and with the great growth in urban population, partly at the expense of the rural, the supply of food for the masses of the people became a serious problem.

Then began a migration of food producers to new lands, the United States, Canada, Australia and New Zealand. Where clearing was necessary, men performed the colossal task of doing in one man's active years what had taken centuries to do in the old lands. Trees were his enemy, ruthlessly to be removed that he might grow wheat for export to Europe. The need was great, there was not a planned programme of land use, and, consequently, exploitative tendencies ruled.

* Summary of the presidential address delivered to the eighth general meeting of the Australian Institute of Agricultural Science at Sydney, March 8, 1946.

Governments receded from directive control of agriculture and left matters largely to the individual. Today, recommendations about proper land use are quite likely to be branded as bureaucratic interference overriding the rights and liberties of the individual. Governments did promulgate protective legislation, such as Quarantine Acts, set up marketing standards for export, develop advisory departments and establish educational institutions.

This was a period of marked advances in the mechanization of agricultural tools, but every such advance made exploitation easier, wider in its scope and more intense in its application. Instead of producing bread from soil, it meant turning soil into bread, as the Rt. Hon. Walter Elliott said " These engines applied to the prairies, gave the world cheap bread—how cheap we do not know till we see how much it costs to replace the skin that has been mercilessly flayed off the United States and sold abroad as bonanza wheat ". With all humility, I think we have to agree that a great deal of investigation and research has had the objective of increased yields rather than economic yield concomitant with maintenance of soil fertility.

World War I again focussed attention on food supplies, and the succeeding years saw a boom with peak production from land at far too high a valuation. Then ensued the depression with an over-supply of some foods but no purchasers, resulting in starvation standards for many while food stocks were dumped and destroyed. During this period attention began to be drawn more and more to the nutritional standards of peoples bringing to light the fact that most peoples of the world were under-nourished so far as protective foods are concerned—milk butter, meat, eggs, fish, fruit and vegetables. In 1934, the Rt. Hon. S. M. Bruce, at a League of Nations meeting, stressed the importance of adequate nutrition, and used the phrase " marriage of health and agriculture " to give point to his thesis. National committees on nutrition were established in a number of countries and much useful work was done before the second world war began. With that war over, we see a new effort in the establishment of the Food and Agriculture Organization of the United Nations, in which Australia is a member nation.

Broadly outlined, it is agreed that each Government undertakes that its people will have adequate food supplies, that all governments will cooperate to help have adequate food supplies for all people, and that the Food and Agriculture Organization will be the focal point for combined effort in the organization of distribution.

World prosperity connotes agricultural prosperity and agriculture, to be prosperous, needs a stable long-term policy fitted to human needs. Such a policy must put an end to dumping. There must be efficiency in economic production and at a level where the producer receives an adequate return for his product while at the same time conserving the national resources in fertile land. The difficulties in implementing these ideals are evident in a world with some highly industrialized nations, and some still engaged mainly in primitive agriculture, with certain nations exporting manufactured goods and depending on others for the import of cheap foodstuffs and raw materials. The proper balance between agriculture and manufacture in, and for, all nations will not be readily achieved, but it is a world-worthy objective.

We, in Australia, hold an island continent with about one-fortieth of its area devoted to agriculture. Two-thirds of the continent (two million square miles) receives less than 20 inches of rain per annum, and so it is on the whole a dry land. We have our own problems, sometimes on a continental scale, and with a small population we have to bear a greater relative load of responsibility than our fellows in more favoured lands.

What, then, are some of the problems ? You know them, but they will bear reiteration.

Public interest has been awakened latterly in the problems of soil erosion, largely because of the dust storms which were common and severe, and because of the publicity given to the " dust-bowl " of the U.S.A. Erosion by wind and water is,

and always has been, a part of nature's programme in the changing topography of the land. We humans, however, must cherish and endeavour to retain that soil which enables us to grow food and related products, not only for our present benefit, but to ensure that in generations to come it will be possible to maintain a population here. Soil conservation, then, is one of our great responsibilities, and soil conservation is so intimately bound with agriculture and forestry and water conservation that we must maintain the widest interests with respect to that work and avoid, at all costs, the restrictions of artificial boundaries, departmental or other. Very obviously, soil conservation is intimately tied with proper land use, whether proper land use involves the afforestation of watersheds, management of the grazing of pastures, or avoidance of monoculture and the establishment of diversification in the farming system.

For food production, it is essential not just to have soil, but to have fertile soil. Since the time of Lawes and Gilbert, who tended to emphasize the value of mineral fertilizers, we have learned much about humus, nodule bacteria, clays, " trace " elements or micronutrients, soil aggregates, and so forth, and it has become abundantly evident that the soil which we need to grow our food is not merely a physical medium, it is truly a biological complex. It is essential to maintain soil fertility, and if we think of fertility as the store of nutritional material held by soil in the intricacies of its physical structure, then studies of the maintenance of soil fertility becoming entrancingly complex. It has to be recognized that, with the increasing mechanization of production, farm manure, except on dairy farms, will become a rarity. Diversified farming and the use of green manure crops therefore become of paramount importance in a planned agriculture.

Climate plays a determining part with respect to the crops which can be grown, which can be used to maintain fertility, how they can be used, what rotations are suitable, whether pastures should be leys or permanent, and so forth. We need to know what are the climatic requirements of crops in order to determine appropriate land use and satisfactory production. In the past, areas for crops have been selected on a trial and error basis, but today, for proposed new crops and in the revision of areas for old crops, it is necessary to be apprised of such factors as sunlight distribution and intensity, photoperiod of the crop, heat units required for maturation, water requirements, and so forth, as well as rainfall and evaporation. In our plant introduction work we endeavour to obtain the fullest " agroclimatological " data, and it is suggested that such studies are an appropriate part of crop establishment programmes.

One of the intriguing advances of this century has been that demonstrating the vital part played in the growth, health and maturation of plants by such micronutrients as zinc, copper, cobalt, molybdenum, etc. Our land may, over wide areas, suffer from deficiency in one or other of these, with consequent effect on the crop and/or stock. Were it not for the modern possibility of a wide exchange of products, man, himself, in some areas could be affected and, indeed, dental conditions today may be determined, to some extent, by micronutrient deficiency.

Reference was made earlier to the fact that this is, on the whole, a dry continent and there is little need to stress the value of water or the importance of water conservation. Departments and commissions are engaged in long-term work aimed at the elimination of floods with their destructive effects by impounding water and controlling its use to good effect. But water conservation can have a more local application on every individual farm and still more detailed application in every square yard of soil where water loss is delayed by the presence of adequate humus content.

In the field of plant physiology, we compound these studies in ascertaining the water relations and requirements of plants, and their major and micronutritional needs for growth, health and reproduction.

The war has taught us much about national food requirements, and an important field of work is that concerning the processing of foods and their transport. I think our colleagues in that field will agree that much remains to be done, and that the means of getting fresh food to our people are sadly inadequate.

You are well aware of the recent developments, startling at times, in weed-killers, insecticides, etc. The use of growth-promoting substances in higher concentration, to serve as specialized weed-killers, of such insecticides as " D.D.T." and " Gammexane ", of anti-biotics such as penicillin, the development of fungicides specially adapted to attack parasite protoplasm, all point to rather amazing possibilities in pest control during the next decade.

There is no suggestion in this address that the treatment is exhaustive, and as time presses, I propose now, briefly, to refer to regional planning. Agriculture is not, or should not be, bound or limited by political fences, and it is proper that the use of Australian land be determined on a basis that is best for the nation now and in the years to come. Surely, if this is so, it must mean regional planning whether the region be large or small, provided it is agroclimatologically sound. One thinks at once of the Tennessee Valley Authority and envisages a Murray Valley regional scheme, a Burdekin region, the region between the Murray and the Murrumbidgee, and so on. I would, however, just like to remind you that there is a great region in north Australia which must command our earnest attention if we are to maintain our right to the retention of that area.

Finally, among the items, but not least in importance, is one that the Institute has interested itself in, and that is agricultural economics. Whatever is produced, the aim must be to produce at economic levels and to market so that both producer and consumer are satisfied.

It is obvious that, more than ever, research will be needed to cope with the many and intricate problems which confront us. But, more than ever, it will be necessary to have the most efficient extension service. As a member of a research organization which has some pride of place in the world, I can say with all honesty that I have the greatest admiration for extension workers. They are of first importance to the agriculturist and to the research worker. They must be able to interpret the one to the other. However they may feel they must always be bright and knowledgeable. They deserve the best of pay and conditions. The point I want to stress is that these keymen are in short supply, and I consider that schools of agriculture should give serious thought to training more extension workers than " ologists ".

Earlier reference was made to the marriage of health and agriculture, and here I suggest that it is not inappropriate to consider favourably the marriage of research and extension work. This can well be accomplished in a regional laboratory where it is possible for research workers to accompany their extension colleagues into the field on occasions and where the extension officer on going home goes to the regional research laboratory. And, in my opinion, it is immaterial who is in charge of any given regional laboratory, whether State or Commonwealth, research or extension officer, so long as he is the right man for the job.

In conclusion, may I say again that in our Institute we have no political boundaries, and no scientific boundaries. Instead, we have great responsibilities in the decade ahead to help guide agriculture in Australia to the end that it may be prosperous and able to play its part in the world.

# Report on Rural Training for Returned Service Personnel*

By

G. A. Currie,
*Vice-Chancellor of the University of Western Australia, Perth, W.A.*

The Commonwealth Reconstruction Training Scheme provides for three types of training :

(1) *University type* handled by the Universities Commission.
(2) *Vocational type* financed through the Department of Labour and National Service, and under the control of the Director of Industrial Training, with deputies in all States.
(3) *Rural training.*

By February, 1944, the University type and Vocational training were working, but no scheme for Rural training had been devised. The author had been working on the University type training scheme since its inception as representative in W.A. of the Universities Commission. When he was asked early in 1945 by the Ministry of Post-War Reconstruction to report on rural training, the knowledge of the general scheme learned in a year's practice of it emboldened him to accept the responsibility.

## Terms of Reference.

The terms of reference were wide, and the following points were noted particularly :

(1) The kind of training which would be most suitable to each category of rural trainee.
(2) The technical experts needed to give intensive training courses and the content of such courses.
(3) The best means of giving practical training to those having insufficient previous practical experience in farming.
(4) Buildings available in each State for training and additions needed.
(5) The administrative machinery necessary to implement the scheme of rural training.

Starting in April, each State was visited in turn to discuss the scheme with a wide cross-section of knowledgeable and interested people. These included Ministers for Agriculture and Lands, State officers in Departments of Agriculture and Lands, Principals and staffs of Agricultural Colleges and Research Farms, Executive members of Returned Soldiers' Leagues and Country Women's Associations and many farmers everywhere.

In each State arrangements were made for follow-up work by the Commonwealth co-ordinators of rural training (usually officers of the Departments of Agriculture) and meetings of co-ordinators were held in Melbourne to get work started even while the investigation was in progress.

In the work of the survey the author was accompanied and assisted by Mr. Roberts, of the W.A. State Department of Agriculture, and Mr. J. Ballantyne, the Commonwealth Co-ordinator of Rural Training of the Ministry of Post-War Reconstruction, and the recommendations in the report owe much to them.

* These are notes condensed from a 50-page report on Rural Training submitted to the Ministry of Post-War Reconstruction. The full text is a confidential document, but by courtesy of the Minister, Hon. J. J. Dedman, copies have been sent to interested people in all States. The original report was prepared and presented by the author of this article, Professor G. A. Currie, and Mr. R. P. Roberts, Agricultural Adviser, State Department of Agriculture, W.A.

The actual time spent on the survey was a crowded eight weeks, spread over four months, in which other work was kept up concurrently. Air travel made possible the production of a report and recommendations to the Ministry at the end of July, just in time to anticipate the end of the Pacific war.

## Training for Farmers.

Universities cater for degree courses in agriculture, Colleges of Agriculture for diploma students. No special training is suggested for farm hands, since vocational training is for skilled workers in apprenticeship trades and agriculture does not figure amongst those. Rural training, then, is meant for farmers, and there are no existing institutions which could handle the numbers likely to require it. Rough estimates made available to us suggested that up to 20,000 persons might be asking for some kind of rural training.

Training for farmers would obviously fall naturally into two sections: (1) practical training on selected approved farms in districts where farming practices would be similar to those of his intended farm, and (2) intensive training in farm management.

*Practical training* was recommended on the basis of two years' continuous full-time experience on approved farms for trainees who had no previous practical experience. A selection board would select those who are to enjoy the benefits of the Land Settlement Scheme and the term needed for practical training might be varied according to the progress of the individual as assessed by a well-balanced committee appointed for the purpose. Trainees would be paid at rates to be fixed by the Ministry while undergoing training, the farmer paying a progressively larger portion of the wages as the trainee becomes more useful to him with experience.

*Intensive training* in farm management would be given in short two months' courses in residential schools established and staffed for the purpose. The establishments would be paid for by the Commonwealth and the trainees paid full-time benefits while at the school.

The intensive courses would be based on the four principles:

(1) Farming as a business.
(2) Farming as a science.
(3) Farming as a practical art.
(4) Farming as a way of life.

Thoroughly practical full-time staff would run the schools and the Principal in each case would have to be a man of special personal qualities, as the success of the school would depend largely on him. All modern aids to study should be adopted, sound films, film strips, illustration and demonstration material, discussion groups with only short introductory lectures.

Mornings would be devoted to the two main courses of farm management and scientific aspects of farming.

Afternoons would include active work on machinery, wood or metal work, or visits to farms or factories. Evenings would be social or semi-recreational with films suitable for "farming as a way of life".

As a basis on which schools could build their time-tables, the following was suggested. Any modification could be made in time or in subject which *would be more suitable to the district.* Local conditions would determine the actual time-table, which should be kept flexible.

Although the intensive courses are suggested as blunderbuss courses to take all intensive trainees, special groups could be arranged for the afternoons if there is a demand for special study of some particular crop plant or some particular stock animal. At such times the appropriate expert would deal with the select group.

*Size of School.* The schools could for convenience be set up in units to take 50 trainees, and the staff for such schools was carefully worked out in conjunction with the Colleges of Agriculture and recommended in the full report. Units of double this size might be more convenient in the larger establishments.

*Proposed Syllabus for Intensive Course in Principles of Farming.*

| Week of Course. | Periods. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 9–10 | 10–11 | 11–12 | 12–1 | 2–3 | 3–4 | 4–5 | Evenings. |
| 1st | Farm Management and Elementary Agricultural Economics. | Animal Production. | Climate. | Farm Engineering and Elementary Veterinary Science. | Practical work in agricultural engineering, elementary veterinary science, classes in carpentry, black-smithing, tinsmithing, classing farm clips, leather work. | | | Documentary films on all aspects of life on farms in this country and abroad. |
| 2nd | | | | | | | | |
| 3rd | | | Soils and Manures. | | | | | Film showing specialist kinds of agriculture, mechanisation in agriculture, rural housing, lighting, water supply, etc. |
| 4th | | | | | | | | |
| 5th | | Pig and Poultry Raising. | Plant Production (including Elementary Pastures). | | Visits to farms, processing plants, stock sales, etc. | | | |
| 6th | | Dairying and Stock Raising. | Crops and Pastures. | | | | | Talks and discussions from adult-education workers on community activities, rural libraries, etc. |
| 7th | | Sheep. | | | | | | |
| 8th | | Poultry (Specialized Course). | Horticulture. | | | | | |
| | Section I. Farming as a Business. | Section II. Farming as a Science. | | | Section III. Farming as a practical Art. | | | Section IV. Farming as a Way of Life. |

## Special Ancillary Aims of Schools.

These short-term schools could not give practical experience nor train skills, but they should give a great deal of thoroughly practical information about the business and science of farming. In addition, they should train the men to use and consult literature on any practical subject and supply them with such useful reports as those of the Rural Reconstruction Commission. More particularly, however, the schools should make the men aware of the vast fund of information available to them at all times from the officers of their own Departments of Agriculture so that they will naturally turn to them for help, information and advice when they get out on their own holdings. Still further, the writer would hope that if these schools prove a success for trainees they should be kept functioning in some form after the reconstruction period is over and become a permanent feature of agricultural extension work in the various States.

## Content of Courses.

Only the skeleton of the curriculum was suggested in the report, but satisfactory arrangements have been made by the Ministry for specially qualified people to write the courses to be given. For instance, the staff of the Division of Rural Economics in N.S.W. is writing an extensive course on the principles of Farm Management and farm accounts, while a course in Animal Production is being written by experts in Western Australia. Whatever may happen to the scheme, such courses will always be most valuable throughout Australia.

### Instructing Instructors.

A course of instruction in modern methods of teaching for instructors was recommended and was given in January, 1946, to representative experts from all except one State. It was held at Hawkesbury College with the collaboration of the Principal and under the direction of the Chief of the Division of Extension Services of the Department of Agriculture, N.S.W. Both in the school and through the printed matter they brought away, the participants benefited greatly.

### Administration of the Scheme.

From the first it was obvious to the author that the State Departments of Agriculture were the only existing organizations capable of handling on behalf of the Commonwealth all aspects of the scheme. In any case it is to their advantage to handle all contacts with the trainees so that they can follow up with extension work after training is over. It was recommended definitely that the State Departments of Agriculture should handle all aspects of the training scheme as agents for the Commonwealth.

The departments will have to arrange the practical training on approved farms, finance the trainees on them, establish, staff and maintain the schools for intensive training, and finance the trainees at them, keep all records and administration details and then recover the finances from the Commonwealth at stated periods.

### Categories of Trainees Eligible for Intensive Courses in Farm Management.

All possible categories of trainees should have the benefits of such a course. It would be an excellent contribution by the Commonwealth to the raising of standards in agricultural practice. Categories suggested are :

(1) Applicants eligible under the ordinary categories of the C.R.T.S. (e.g., under 21 at enlistment and intending to be farmers, etc.) who have had enough practical experience.
(2) Applicants eligible for " refresher " courses in farming (all farmers or farmers' sons who went into services should be eligible under this category).
(3) Applicants for rural loans who might elect to take and be granted the course.

### Present Position.

At the time of writing buildings are prepared or are being prepared in all States for the intensive courses, some men are undergoing practical training on approved farms, and the Commonwealth has agreed to finance the main provisions of the scheme through the State Departments of Agriculture.

It is interesting to note in conclusion that in all States we met questions about land settlement schemes and the responsibilities which should rest on Governments which encourage them. We replied that our concern was *training*, not *settlement*. We did not find anyone in our travels who thought that some training for the complex job of farming was unnecessary. The conditional phrase which accompanied agreement with the need for training was, of course, that training, whether on farms or in the intensive course, should be thoroughly practical. We agreed.

### Acknowledgments.

Acknowledgment is freely made for cordial advice and ready assistance from all with whom we made contact. Naturally Institute members were conspicuous amongst them. Special thanks are due to Professor Wadham, both because the survey was undertaken on his personal representations and because so much that was useful was culled from the reports of the Rural Reconstruction Commission written by him and his colleagues.

# Subsidies for Approved Soil Conservation Practices

By

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The United States Soil Conservation and Domestic Allotment Act (1936), and later the Agricultural Adjustment Act (1938), contained some significant measures unique in agricultural legislation. Under the provisions of these Acts, farmers who carried out prescribed soil-conserving practices and who conformed to a predetermined pattern of farm production were eligible to receive direct government subsidies on a *pro rata* basis.* Incentive payments of a similar kind have been used on a limited scale during the war period in certain other countries, notably the United Kingdom,[2] Canada[5] and Rhodesia.[4] The objective in these cases has been one of assisting in the achievement of a desired pattern of agricultural production.

The advisability of introducing incentive payments, or conditional grants (as they are sometimes called) as an integral part of the government agricultural programme in this country, has been discussed at various times in recent years. It has been pointed out that such measures would facilitate the more rapid adoption by farmers of improved agricultural practices and could be effectively used to promote more widespread conservation of the soil by individual farmers. The proponents, also, quite rightly, insist that incentive payments for specific practices are a type of subsidy to be preferred to direct price subsidies paid to primary producers. For instance, they assert that, had the £7 million appropriated annually as a subsidy to dairy farmers been paid in the form of incentive payments for improved farming practices rather than as an overall price increase, the dairy industry would have shown improvement in production instead of retrogression.

Most discussions of incentive payments stress the physical benefits to be expected as a result of such a plan and give little or no attention to the costs and administrative difficulties which would be associated with its implementation. Soil conservation or increased production (whatever the objective might be) is regarded as a virtue irrespective of cost. Such an attitude may be defensible in time of war, but certainly no long-term programme should be initiated without some attempt to weigh the advantages of such a scheme against the expenditure of public funds involved. This article represents an attempt to outline some of the wider implications of subsidy schemes of this nature. This discussion is largely in terms of soil conservation measures. However, the same sort of considerations are involved in the provision of incentive payments for other ends, although such ends may be much less justifiable as objects of public expenditure.

## Government Subsidies for Conservation on Private Lands.

Two arguments are commonly advanced in favour of a government offering incentive payments for soil conservation practices. In the first place, it is suggested that they would enable many farmers to carry out conservation practices that otherwise would be too expensive. Secondly, it is pointed out that the monetary incentive would awaken the interest of many farmers who otherwise might not be reached.

* The basic reason for the introduction of these measures was the legal *impasse* occasioned by the invalidation of the production control provisions of the Agricultural Adjustment Act (1933). This article deals with incentive payments as genuine soil conservation measures, rather than as a form of production control.

The validity of the first argument rests largely on the correctness of an implicit assumption that most conservation measures are uneconomic for the individual farmer. This fact is presumed to explain the failure of farmers to practise soil conservation. Some observers,[3] on the other hand, assume, without investigation, that conservation farming is more profitable than exploitive farming. They attribute the farmer's failure to adopt appropriate farm practices to various institutional and economic factors inhibiting change. Neither contention is an altogether correct representation of the position. However, such diversity of opinion does draw attention to the urgent necessity of initiating research to determine the profitableness of various practices in specific instances. Detailed government programmes of the type under discussion should be based on more than mere assumptions as to the circumstances they are designed to correct.

If factual evidence were available showing that, even though it would pay him to carry out soil conservation measures, the farmer did not follow the indicated line of economic advantage, the case for the payment of a subsidy would be considerably weakened. In these circumstances it would be desirable to have some indication as to what were the basic reasons behind the failure to conserve the soil. Some possible explanations of such inaction on the part of the farmer are discussed below. Suffice it to say here that, if investigation proved, for instance, that shortage of short-term capital was chiefly responsible, then money would be better spent in overcoming this impediment than in making grants to farmers. In any case, it is a moot point as to whether it is desirable for the farmer to be subsidized for undertaking practices which, even without monetary assistance, it is in his own economic interest to carry out.

On the other hand, investigation might show that from the standpoint of the individual farmer it would not pay to take steps to conserve the fertility of the soil. In such circumstances, it is said that society, which has longer-term interests than the individual, should intervene and assist the farmer to carry out the work necessary to maintain fertility. Questions of maintaining soil assets intact for posterity, of protecting the property rights of others, of preventing siltation of rivers, and so on, are all involved. It is in social considerations such as these that the problem transcends the sphere of economics and becomes a problem in political science. Even so, that does not mean that economic costs and benefits should be overlooked. There must be an attempt to evaluate the extent to which expenses of this nature are justified. Admittedly, the problem is difficult, but it is in the public interest that a government should not appropriate funds to a scheme of this nature without some definite idea as to the tangible benefits such expenditure might bring.

The second argument put forward in favour of incentive payments has reference to their value as means of attracting the farmers' interest. If monetary rewards have to be offered to farmers to induce them to adopt improved methods, it is either a sorry reflection on agricultural extension organization and methods or on farmers themselves. However, it would be very difficult to make out a case to justify the use of public funds for such ends.

Obviously any expenditure of public moneys must involve a weighing of the relative priorities of various alternative purposes for which the money might be made available. For instance, the question may arise as to whether money would not be better devoted to water conservation projects than in subsidizing soil conservation practices. This is a type of question which Parliament alone can decide.

### Possible Types of Direct Subsidy.

If a government were convinced of the social, if not of the economic, desirability of subsidizing soil conservation practices on private farms, there are four possible ways by which such a programme might be implemented.

(i) *Cash Payments.* Incentive payments may be made by the government to individual producers who carry out specified conservation practices. These subsidies may be of three types :—(*a*) Payments made on a *pro rata* basis for specific

practices carried out by the farmer. The scope of practices covered would be determined by the magnitude of the programme. It might include such practices as application of fertilizer, building of contour banks, ploughing in green manure crops and tree planting. (*b*) Payments made for the acreage of soil-conserving crops planted. (*c*) Payments made for the acreage of soil-depleting crops diverted to other uses, as for example, the diversion of wheat land to lucerne. The Commonwealth Government used a scheme of the latter class to curtail the acreage under wheat in Western Australia in the 1942-43 and subsequent seasons. All three types have been used under the United States' Agricultural Adjustment Administration programmes. Emphasis has been laid more and more on types (*a*) and (*b*). Payments for negative action (type (*c*)) are not a desirable form of public expenditure.

(ii) *Provision of Conservation Materials or Equipment by Government Agencies.* As an alternative to a cash subsidy, it might be more desirable for farmers to be provided with conservation materials by government agencies. These might take the form of fertilizers, tree seedlings or pasture seeds. Such a programme might possibly be supplementary to that mentioned above, the cost of materials supplied being deducted from the total amount of the subsidy. For obvious reasons, it would be inadvisable for a government to make any of the materials available free of all cost to the farmer. At least a nominal sum should be paid by the recipient. In a similar fashion, heavy or specialized agricultural machinery might be made available at low contract rates for special jobs which are beyond the capacity of the average farmer's machinery resources. Some precedent exists for this class of subsidy. Between 1932 and 1939 the Commonwealth Government subsidized the use of superphosphate for specific purposes to the extent of £1·8 million.

(iii) *Amendment of Income Tax Legislation.* A third method, though somewhat less administratively feasible, would be the revision of income tax legislation to provide for adequate rebates for money expended on bona fide soil conservation work, or for crop land left under permanent vegetative cover. The Graziers' Federal Council of Australia has made representations along these lines to the Federal Treasurer within the last twelve months.

(iv) *Use of Price Control.* Under conditions of administrative price-fixing for primary products, it may be possible to maintain the returns per acre from soil-conserving crops above those from soil-depleting crops. However, no attempt has yet been made to induce conservation by such an extreme form of price manipulation. Price changes would probably have to be very substantial if they were to effect any significant change in rural land use. The severe repercussions which such a scheme would have on the farm price and income structure would be so serious that it will probably remain a purely theoretical alternative.

### Factors Inhibiting Adoption of Soil Conservation Measures.

Attention has been directed above to the fact that, whatever type of assistance is given farmers, it should be directly related to the specific social and economic forces obstructing the general adoption of soil-conserving practices on individual farms, if it is to be successful. While the provision of a subsidy may, in some cases, make it economic for the individual farmer to undertake some soil-conserving measures, very often the reasons for non-adoption of control measures are more fundamental than the fact of their being uneconomic. Subsidies, *per se*, do not remove these causes. They are therefore unlikely to be efficacious unless they are associated with supplementary programmes aiming to assuage or eliminate the more important factors inhibiting adoption of soil conservation measures.

Probably the most fundamental reason for the existing state of affairs is the attitude of the farm population towards the soil and its conservation. To a large extent, this may be a reflection of the extensive nature of Australian agriculture, compared with, say, the intensive type of agriculture practised in western Europe. Custom and inertia are probably important reasons why such an attitude towards the

land does not change readily. On the other hand, the farmer may be conscious of the need to do something about the erosion of his land, but may lack knowledge as to ways and means of taking steps to arrest it. The solution in such a case would be one of providing greater educational facilities to farmers.

From the standpoint of the individual farm there may be very pertinent reasons why conservation measures cannot be practised. Shortage of capital or lack of access to sufficient sources of credit at a low rate of interest may limit such activities. Adequate suitable equipment and machinery necessary for mechanical erosion control may be lacking. Systems of land tenure may be such as to favour insecurity of occupancy and hence discourage long-term investment. Purely local factors, such as the magnitude of the mortgage debt, or insufficient size of the farm, may prevent expenditure on soil conservation and necessitate working the existing area of land in a prodigal fashion. All these matters might well be the subject of specific government intervention. Improvements in the agricultural credit system, organization of contract machinery services, reconstruction of farm holdings and improved land tenure and zoning legislation represent ways in which a government can assist towards the achievement of a greater measure of agricultural conservation.

Of more general application as a probable explanation of the limited adoption of erosion control measures is the fact that agricultural prices and incomes have been characterized by considerable instability in the past. Insecurity and uncertainty arising from fluctuating prices and incomes may well cause the farmer to hesitate before embarking on any programme of soil conservation. This virtually emphasizes the need for attention to farm income stabilization measures as an integral part of any sound soil conservation policy.

### Objections to Subsidies for Soil Conservation Practices.

Quite apart from the fact that government subsidies are not the complete answer to the problem of combating soil erosion, there are other problems connected with the administration of such a programme which are deserving of close examination.

First, there is the problem of designing the programme so that it will give the specific results desired of it. Attention must be directed to possible secondary effects. For instance, if the scheme were to apply to an entire State (open discrimination between areas would be politically impracticable) it may be that farmers on strictly marginal lands may receive incentive payments in sufficient amounts to permit them to eke out an existence while waiting for one or more bumper crop years. Even within local areas, payments may be made for the performance of operations not suited to, or needed for, the farms on which they are carried out. For example, farms on relatively flat country, where the prospective danger from water erosion is comparatively insignificant, may be eligible to receive the same payment for contour practices as farms on an undulating to hilly terrain. At the other extreme, in areas of varying land types, farmers may be encouraged by the monetary rewards offered to carry out practices which are not justified on land of poor quality. To some extent, this trouble might be mitigated by adapting the range of practices for which payments are made to the topographic and agronomic conditions in different areas, as was done under the United States A.A.A. programme. Even were this done, it would be exceptional if local administrative areas were characterized by a homogenous land type. The impracticability of giving the local administration discretion to differentiate between the erodibility of various soil types in granting subsidies is obvious.

From the agronomic standpoint there is also a danger that sound rotation systems may be upset in order to qualify for incentive payments. To meet difficulties such as this, it may be possible to devise some scheme whereby payments might be given as rewards for properly conducted systems of farming, with farms treated as units, rather than as payments for specific practices.[1] This would also tend to limit the possibility of farmers fulfilling an agreement merely to earn extra money,

while giving little concern to conservation or improvement of the soil as a desirable objective in itself.

Introduction of a large-scale soil conservation programme may have profound repercussions on the agricultural economy as a whole. Any scheme, which has as its object the diversion of land from its accustomed crop pattern to other uses, must tend to discourage regional specialization in production. This, in turn, may mean a corresponding decrease in efficiency and a rise in production costs. The encouragement of soil-conserving crops at the expense of soil-depleting crops, which are principally cash crops, may also tend to affect seriously the long-term stability of the livestock industries.

Another undesirable feature of subsidy programmes is the fact that voluntary capital maintenance, which would be undertaken by individual farmers without subsidy, is discouraged. Some farmers would be paid for what they would have done voluntarily. Furthermore, were a subsidy scheme of limited duration introduced, the government would have no assurance that money expended to encourage soil conservation would not be lost through the bad farming practices of the present or subsequent land occupier in future years.

It would prove exceedingly difficult to estimate, in advance, the probable size of the appropriation which would be required to meet bona fide commitments, if any one type of subsidy for a specific practice were to become a reality. Nevertheless, some estimates of both the probable cost of the subsidy and the cost of administration would have to precede any organized move to introduce such a scheme. Experience in the United States indicates that subsidy programmes of this nature are extremely complicated and costly to administer. It is essential to have provision for some local administration to inspect and appraise the work done by farmers and verify their eligibility to receive their respective payments. In the United States programme in 1943, 400 million dollars were paid to farmers, 132,000 people were employed in its administration and administrative expenses amounted to about 43 million dollars.[7] Local administrative expenses were met, in part, by a levy on payments farmers received. In some counties over 20 per cent. of farmers' payments were absorbed in paying the administrative expenses.[6]

American experience also shows that subsidy schemes of the type under discussion may result in an undesirable redistribution of income. Farmers receiving low incomes, who probably require conservation payments most, tend to receive much less than farmers in the higher income bracket. Farm operators with large areas and adequate capital reserves are better able to undertake soil-conserving measures on their properties and hence are eligible to receive larger payments from government funds. One analysis of A.A.A. payments in the United States showed that the low-income bracket of farmers, representing 47 per cent. of the total number of farmers, received 11 per cent. of the money distributed, whereas large-scale operators representing approximately 11 per cent. of the total received 47 per cent. of the money distributed.[6]

## The Subsidy Question.

A consideration of the advisability of introducing measures along the lines suggested above impinges on a much wider issue—the question of permanent subsidies to primary industries. The proposal, while it is intimately linked with the praiseworthy objective of soil conservation, does involve increased government subsidies to agriculture. From one point of view incentive payments involve a more insidious form of subsidy than those currently paid, in that they are disguised as payments for conservation practices. In such a form, farmers who received them could quite easily overlook the essential subsidy nature of the payments.

No satisfactory system of permanent agriculture can be dependent on subsidies for its continuance. At a time when increased agricultural efficiency and low cost production are more than ever necessary, any move to increase subsidies to

agriculture, however superficially justified, cannot be regarded in a favourable light. The problem of soil conservation can be tackled without resorting to the payment of permanent subsidies to individual farmers.

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# Tabulation of Farm Surveys in Australia and New Zealand and a Discussion of the Field-Interview Method*

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Farm management surveys in the United States have recently been reviewed by S. W. Warren.[31] In the present paper tables are given showing the extent of similar work in Australia and New Zealand. The rest of the paper is devoted to a discussion of some aspects of the field-interview method of conducting farm surveys.

Tables 1 and 2 comprise a record of farm surveys in Australia and New Zealand. There are thirty-eight surveys of various kinds listed. As many of the surveys tabulated have not yet been published, it is impossible to draw distinctions between those surveys which have employed the " mapping ", the " field-interview ", the " account-keeping or costing " or any other methods. The tables comprise a record of projects in which material primarily of an agricultural economic nature has been collected personally in the field by an investigator. As far as is known, only those projects have been listed which represent at least a year's full-time work.

The " field-interview " method is one of three ways of conducting farm surveys. The other two methods are " mapping " and " account-keeping or costing ". If the opportunity exists for a comprehensive approach it is preferable in point of time to commence work with a " mapping " survey, follow it with a " field-interview " survey and finally to conduct an " account-keeping or costing " survey. In the writer's opinion it is the particular job of the " field-interview " surveyor to discover what incomes farmers are earning and what factors are affecting the size of their incomes. Neither mapping nor account-keeping methods are particularly suitable for this work. What is required is the statistical analysis of large numbers of first-hand farm records. Each of the three methods—mapping, field-interview and account-keeping—may be used to collect information which will assist economists, adminis-

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TABLE 1.

*Studies of Land-Use, Farm Management, Costs and Rural Sociology in Australia.*

| State. | Region. | Area. Square Miles. | Class of Farm Industry. | Object of Study. | Proportion of Farms Surveyed. | Field Mapping Done. | Reference Numbers. |
|---|---|---|---|---|---|---|---|
| N.S.W. | Lower Hunter .. .. | 1,100 | Dairying, orchard, vegetables. | Land-use. | 5/? | Land-use. | (15) |
| ,, | Tamworth .. .. | 1,000 | Wheat, sheep, dairying. | Do. | About 1000/1000. | Do. | W. H. Maze.* |
| ,, | Kurrajong-Windsor .. | 580 | Dairying, orchard, vegetables. | Do. | All farms/?. | Do. | (16) |
| ,, | Wakool .. .. .. | 830 | Sheep (mainly). | Land values–costs. | 18/110 | Soil. (24). | (23) |
| ,, | Murrumbidgee I.A. .. | 53 | Irrigated horticulture. | Tree health–land use. | 1043/1043 | Do. (30).‡ | (14) |
| Vict. | Berwick .. .. | 50 | Dairying and mixed farming. | Soil–land use. | 192/192 | Do.–land-use. | (13) |
| ,, | Koo-wee-rup .. .. | 81 | Dairying (mainly). | Do. | 61/438 | Do. | (10) |
| ,, | Wheat-belt .. .. | 16,000 | Wheat. | Sociological. | 138/7500 | None. | A. J. Holt.* |
| ,, | Dairying areas .. | 12,000 | Dairying. | Do. | 260/13000 | None. | M. Rothberg.* |
| ,, | Mildura .. .. .. | 60 | Irrigated vines. | Do. | 150/1600 | None. | A. J. McIntyre.* |
| S.A. | Central division .. | 2½ | Wheat. | Costs. | 1/1 | None. | (18) |
| ,, | Mallee division .. | 2½ | Do. | Do. | Do. | None. | (19) |
| ,, | Part Co. Grey .. .. | 500 | Sheep, dairying, forestry. | Soil–land use. | 372/372 | Soil–land-use. | (25) |
| ,, | Part Co. Victoria .. | 600 | Wheat and sheep. | Soil–land-use–erosion. | 500/500 | Do. and erosion. | (27) |
| W.A. | Wheat-belt .. .. | 60,000† | Wheat. | Costs. | 67/200† | None. | (20), (21) |
| ,, | Wheat-belt .. .. | Do. | Do. | Do. | 46/4000† | None. | R. P. Roberts.* |
| ,, | Belka Valley .. .. | 113 | Do. | Do. | 25/38 | None. | F. O. Grogan.* (11) |
| ,, | Busselton-Margaret R. | 20 | Dairying. | Farm management–income. | 23/27 | None. | (22) |
| ,, | Margaret River-Nannup | 2,055 | Dairying. | Do., do. | 120/400 | Soil. (26). | S. Rowley.* |
| ,, | Avon Valley .. .. | 2,016 | Cereals and sheep. | Do. | 85/752 | None. | S. Rowley.* |
| — | Commonwealth basis .. | 38,000† | Dairying. | Do. | 450/45000† | None. | (8) |
| — | Goulburn Valley (Vic.) and Murray Swamps (S.A.) .. .. .. | 1,700† | Do. | Do. and income. | 97/1600† | S.A. soil. (29). | (1) |
| — | Murray Valley—Vic. and N.S.W. .. .. | 50† | Irrigated citrus. | Do. and costs. | 91/3500† | None. | (2) |

* Unpublished studies. Information regarding these and other projects was kindly supplied by Messrs. F. O. Grogan, G. W. Leeper, Prof. MacDonald Holmes, Messrs. R. R. Pennefather, R. P. Roberts, R. Smith and C. G. Stephens.

† These figures are approximate.

‡ Also unpublished maps of land-use.

trators and farmers. The methods are complementary rather than competitive. As the number of farms which can be handled in an account-keeping survey is low, it is reasonable for such work to follow after the general field-interview survey which collects more records. The field-interview survey can only be satisfactorily conducted after a mapping survey has defined the soil types or the land classes. It is clear that each type of survey can be made more valuable if planned with the needs of succeeding investigations in mind. The economic and administrative problems of farming, although so complex, have attracted the attention of only a few agricultural scientists, geographers and economists. Those who are at present appropriately trained for farm surveying are by no means numerous. It is therefore important that such farm surveys as are done should be so organized that the maximum amount of reliable and useful information is produced for the time and effort expended. It is within the province of the trained statistician to help in such studies. In other words, team work is essential not only in the field but also in the planning and analysis of farm surveys, if the best use is to be made of the services of the few available farm surveyors.

TABLE 2.

*Studies of Land-Use, Farm Management, Costs and Rural Sociology in New Zealand.*

| Region. | Area. Square Miles. | Class of Farm Industry. | Proportion of Farms Surveyed. | Field Mapping Done. | Reference Numbers. |
|---|---|---|---|---|---|
| *North Island—* | | | | | |
| Waikato and Taranaki .. | 35 | Dairying. | 206/? | None. | (6) |
| Te Awamutu .. .. | ? | Do. | 9/? | None. | (28) |
| Dairy districts .. .. | 215 | Do. | 967/? | None. | (7) |
| Dairy districts .. .. | 107† | Do. | 550/21, 651 | None. | (17) |
| Citrus districts .. .. | 40† | Citrus. | 42/358 | None. | (12) |
| Hobson Co. .. .. .. | ? | Dairying. | 100/? | None. | W. R. P. Begg.* |
| Heretaunga Plains .. .. | 133 | Stock - fattening, dairying, fruit grass seeds. | 250/600† | Soil-crops. | (4) |
| Dairy districts .. .. | 6,000† | Dairying. | 452/36000† | None. | (5) |
| *South Island—* | | | | | |
| Springs Co. .. .. .. | 90 | Mixed farming. | 30/200 | None. | C. E. Iversen.* |
| Part of Canterbury .. .. | 9,000 | Sheep. | 40/400 | None. | (32) |
| Springs Co. .. .. .. | 90 | Mixed farming. | 30/200 | Land-use. | (33) |
| Part of Canterbury .. .. | 1,000 | Do. | 50/1800 | None. | A. F. Greenall.* |
| Co. Ashburton, Mountain Area | 1,300 | Sheep and cattle. | 10/50 | Land-use. | C. E. Ballinger.* |
| Co. Ashburton, Plains Area.. | 1,172 | Wheat and sheep. | 350/1800 | Land-use. | (9) |
| South Canterbury Foothills.. | ? | Do. | ? | None. | E. M. Ojala.* |

* Unpublished studies. Information regarding these and other projects was kindly supplied by Mr. R. P. Connell, Dr. W. M. Hamilton, Mr. H. B. Low and Dr. I. W. Weston.

† Approximate figures only.

## Field-Interview Method.

The collection of records and the interpretation of records are two separate phases of farm survey work. The field-interview type of farm survey is distinguished by the fact that the *collection* is made on farms by means of personal interviews between farmers and the investigator. The collection of records is a relatively straightforward matter of devising a questionnaire to elicit information of a definite nature; the actual interview itself poses interesting problems which will not be discussed here. The number of farms which can be handled in a survey is determined by the time which can be spent in the field, the density of settlement, the length of the questionnaire and the means of transport available. The rest of this paper is devoted to questions of *sampling* and *interpretation*.

### *Terminology.*

Two points of terminology should be clarified at this stage. In the first place we should sharply differentiate the three possible and separate methods of collection, namely mapping, field-interview and account-keeping. Workers at Cornell have so consistently used a combination of mapping and field-interview that the separate

identity of these two methods has been obscured under the single title " farm management survey ". In itself the phrase " farm management survey " indicates the method neither of collection nor of interpretation. By connotation the phrase has come to mean " a farm survey which is to be analysed statistically, the collection being by field-interview and not by account-keeping ". Mapping has been regarded as a necessary adjunct to the field-interview. In the second place, terminology could be made more precise by consistently using the phrase " block farm surveys " to describe the selection of farms all in a contiguous block (as in the New York surveys). The phrase " sample farm surveys " could be used to describe surveys in which isolated farms are selected scattered over wider areas. Whilst a " block farm survey " may be more appropriate for mapping work, a " sample farm survey " is certainly more efficient for field-interview work. In the subsequent discussion of sampling, the " block farm survey " may be regarded as a special case in which the " sample " and the " population " are identical.

*Development of the Field-Interview Method.*

There are two distinguishing features of the farm management survey as developed by G. F. Warren. In the first place the collection is made by means of a field-interview using a relatively simple schedule (or questionnaire), and in the second place the interpretation is made by the statistical analysis of records from a relatively large number of farmers. The most efficient type of field-interview method in use today has been developed from G. F. Warren's method of collection by field-interview (not necessarily using mapping) and from his method of interpretation based on statistical analysis. However, in order that the fullest use may be made of statistical analysis, Warren's " block farm survey " may be dropped in favour of Bowley's[3] method of selection by random sampling.

When the field-interview type of sample farm survey is compared with alternative methods of enquiry, such as the census or mailed questionnaires, its advantages are apparent. In the first place, there is little possibility of misinterpretation of data as the records are collected personally. Secondly, the method is equally suitable for studies of land use and farm management, and for simple studies of costs and sociological questions. Thirdly, the field-interview method has the advantages that the enquiry is relatively quick and simple and that only rare farmers will not cooperate. So it becomes possible to regard the records of cooperating farmers in a random sample as a true random sample of the *population* or *universe*. Lastly, the bulk of field work is reduced by virtue of the random sampling. Thus the method just described for the collection and interpretation of farm records offers accuracy, adaptability, speed and economy of effort. However, the fullest economy of effort can be secured only when farm surveys are planned in advance to coordinate the results of the three methods, mapping, field-interview and account-keeping.

*Sampling and Location of Farms.*

The purpose of statistical sampling is to reduce the number of cases under investigation in such a way that conclusions may be drawn from cases representing only a fraction of the population or universe ; these conclusions can then be validly referred back to the original population. In a field-interview survey the population may be all the farmers in a farm industry, all the farmers in an area, or all the farmers in a combination of industry and area. Sampling is appropriate in each case. For example, if the industry or farm class contains more than 200 cases it will probably be necessary to select some fraction of the whole for detailed survey in a period of twelve months. If an area to be surveyed is such that the whole region can be covered (by the block farm survey method), then the farms to be surveyed will lie more or less contiguously to one another in a compact stretch of farming land. This may occur if the area is not greater than one hundred square miles, the size varying

with the density of settlement ; but if the region is too large to be surveyed in full, then sampling methods are necessary. A Commonwealth-wide population may be reduced in the first place by selecting a relatively uniform climatic region for the survey ; then a sample may be selected at random from the specialist farmers in that region. A sample farm survey is less suitable than a block farm survey for studies of mixed farming, and for this reason no consideration is given to the special case of sampling from a population of " mixed farmers ". It is true that no region, however small, is quite uniform climatically ; nor is the degree of specialization exactly similar on all specialist farms in any group, however carefully chosen. Nevertheless, no attempt will be made here to justify the assumption of comparative uniformity in these elements. Some of the particular aspects of surveying each type of population will now be discussed.

(1) *Surveying an Industry.*

The industry forms the logical basis for the population where the purpose is to study the methods of farm management or simple aspects of costs in a specialist class of farming. In the Australian census of 1933 twenty-five classes of the farming industries were listed for the Commonwealth, ranging in size from " mixed farming " (159,000 men) down to " coconut growing " (14 men). Thus in practice it is usually necessary to restrict the population, and to survey only a part of an industry ; this is best done by confining the survey to the specialist farmers in one climatic region and then applying random sampling methods as described in section (3) below.

(2) *Surveying an Area.*

When the main intention is to study the use of land rather than the status of an industry, it is desirable to define the population on the basis of area rather than industry. Alternative types of agricultural use can be studied more effectively in this way, and competing uses such as forestry can also be considered. The chief objection to surveys of areas is that every area is in some sense unique, so that the results have only local application. It is true that the results of each survey do refer to a rather small area. At the same time random sampling and the consequent reduction in field work make for such speed in surveying that the number of local surveys may be rapidly increased. Reliable knowledge of a number of areas can only be secured from a number of surveys. No one survey can provide all the answers.

(3) *Surveying an Industry in an Area.*

It may be more convenient to select the population on the joint basis of both industry and area than on the basis of either alone. Also by basing the population jointly on industries and area it is possible to study farm management in one or more industries simultaneously ; the whole area is taken as the population, and sampling methods are used in relation to the main industries within the area, say dairying and orchard work.

*Sampling the Population.*

Clearly the sample may be drawn from any one of the three types of population outlined above. The investigator can save much fruitless labour if he gives due attention to his methods of sampling. The temptation should be avoided to interview *only* those farmers who are

(*a*) particularly cooperative,
(*b*) prosperous and progressive in farming methods,
(*c*) prominent in local organizations,
(*d*) easily accessible by good roads,
(*e*) old residents in the district.

Opinions based on information secured from such sources are obviously biased. Some investigators, although well aware of the place of random sampling in other

spheres, fail to adopt this method when handling social and economic problems. The sample of farms included in a survey may be located throughout the continent or region, and may be selected by any of the following methods :

(i) random sampling methods,
(ii) stratified random sampling methods, the strata relating to the size of farm holdings, local government boundaries, soil zones where known, or any such factor which may be determined prior to survey,
(iii) purposive selection of one or more relatively small compact localities in the continent or region which are chosen (from a previous knowledge of farming and of the region) as being in some sense typical of the whole population.

The last method is the least desirable, as it gives scope for bias in the selection of the typical localities. Whatever method is used, it should always be borne in mind that the results and conclusions from the sample surveyed cannot be extended to apply to any population other than that from which the sample was originally drawn.

Various methods of defining the population have been outlined in preceding paragraphs. So far it has been assumed that random sampling may be applied as soon as the population is defined. There is a further difficulty to consider. It is the question of what proportion of the original population provides an adequate sample. This is a statistical question. However, before statistical methods of sampling can be used various elements must be known. They are the *population*, the *variables* and the *range of variation*. It is immediately apparent that ideally the investigator should know something of the range of variation of his data before he commences his detailed field survey ; that is to say, he should be familiar with the type of farming he wishes to survey. It may be worth his while to make an initial reconnaissance survey, if suitable information cannot be obtained in any other way. Even supposing this has been done, there may be some difficulty about determining what number of farms should be included in a sample. As a complex situation has to be analysed, the only safe rule is to err on the generous side. Low percentage samples such as are used in Gallup polls, although effective in measuring opinions of the yes/no type, cannot be adopted in field-interview work. A 2 per cent. sample is not as good as a 10 per cent. one, and a 20 per cent. sample would probably be better still. When more surveys have been made and the range of variation of the variables is better understood and their relative importance known, then it will be possible to determine more accurately what size a sample should be in relation to any population.

*Interpretation of Records.*

The number of determining variables recognized will ultimately depend on the object of the survey. For certain practical purposes it may well be reasonable to give prominence to otherwise minor variables. Each variable may exhibit a wide range of variation not only throughout each class of farming, but even within one class of farming in a relatively small district. It is on the range of this variation and on the interaction effects between variables that the optimum size of samples will partly depend. The measurement of the variables is a subject of great interest. Only a few remarks will be made on it here.

There are seven important variables to be measured quantitatively in field-interview surveys. The five *determining* variables are

(i) land class (defined on a natural basis),
(ii) effective farm size (in cleared arable acre equivalents),
(iii) labour-units on holding (in man-equivalents),
(iv) capital equipment on holding (in monetary terms),
(v) farm enterprise (in terms of census classification of farm industries).

There are two aspects of the *predictable* variable—

(vi) yield of specialist product (e.g., bu. wheat, lb. butterfat or lb. wool),
(vii) operator's farm income (difference between farm income and farm outlay).

It is clear that the five determining variables operate whether the farm industry is agricultural, pastoral or dairying. Together they determine the relative position of each farm in relation to every other farm in the population in respect of the predictable variable in any particular year. Until some worthwhile measure of managerial ability has been devised, it will be impossible to measure its effect on farm yield and income. Complications arise in surveys which are intended to show comparisons over periods of time, not only on account of variable seasons but also because of variable costs and prices; the complications will not be discussed here. A knowledge of economic theory relating to production gives some support to the choice of these variables. The " factors of production " postulated in economics correspond roughly to the determining variables as follows:

| *Determining Variables* | *Factors of Production* |
|---|---|
| Land class | =Land—its quality |
| Effective farm size | =Land—its quantity |
| Labour-units on holding | =Labour |
| Capital equipment on holding | =Capital |
| Farm enterprise | =Generally regarded as one aspect of farm management, rather than as a factor of production. |

The phrase " farm enterprise ", as used in technical literature in the United States, means the organization of a farm for the production of a special line, such as wheat. Where wheat and wool are both produced on one farm, there are two farm enterprises. It will be clear to readers interested in economics that the way in which the word " enterprise " is used here is not the one with which they are familiar.

*Contra-Indications.*

There are certain pitfalls peculiar to farm survey work which deserve attention. It is unfortunately true that carelessness regarding statistical planning and analysis has been common. First and foremost it is necessary to stress the obvious precaution that where sampling is used it should be *random* sampling. Next, the sample should be large enough to demonstrate the influence of the main determining variable. Then, statistical measures of reliability should be calculated for the parameters disclosed. Finally, there are two other types of weakness which farm surveyors have exhibited in the past. The most likely trap for the unwary economist is to neglect to collect information in physical terms regarding yield of specialist product. The careless scientist will be more likely to neglect to record the number of labour units on each holding.

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# The Movements of Calandra Oryzæ L. (Small Strain) in Experimental Bulks of Wheat.

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The restriction of the insect infestation of bulk wheat to the surface several inches of the wheat, was a general characteristic of the insect infestations in bins and bulkheads in Australia during the war years, when wheat had to be stored for prolonged periods.(1) In some cases the insects may have been introduced only at the surface ; this would be so in the case of a clean bulk of wheat becoming infested after it had been stored. But it would still be necessary to explain the failure of the insects to migrate to the deeper levels and colonize them. It is more likely that in most cases the insects were introduced more or less at random during construction, some in the depths and some on the surface. It is necessary in these cases to explain the failure of infestations to develop in the depths.

Henderson and Oxley(2) have shown that the coefficient of diffusion of carbon dioxide in wheat is about one-third of that in open air. It is therefore unlikely that sufficient carbon dioxide would accumulate in the depths to prevent the multiplication of insects. Some other factor such as a tropism may guide the insects to the surface and keep them there. Little is known of the way in which insects move in wheat. Voûte(3) states that *C. oryzæ* tends to move from places where it is present at a high density to those of lower density.

* This work was carried out with the aid of a research grant from Federal grant to the University of Adelaide.

The experiments described in this paper were done in order to find out how *C. oryzæ* moved about in a bulk of wheat, precautions being taken to prevent the accumulation of carbon dioxide. Experiments were also planned to determine if insects could multiply in such a bulk when placed 4-5 ft. below the surface.

The wider problem of the " heating " of bulk wheat and the relation of this to surface infestation will be discussed in another paper.

## Experimental Technique.

Small experimental bins were constructed of caneite. They measured 1 ft. × 1 ft. × 5 ft. high and held four bushels of wheat. A well-fitting lid sealed with felt prevented the insects from escaping. In both the lid and the floor there were four large holes covered with phosphor-bronze gauze. The bins stood vertically on legs two inches off the floor, so that diffusion of air could take place through the depth of the bin. Thermometers were inserted through the walls at depths of 1 ft., 2 ft., 3 ft. and 4 ft. from the top, so that the bulbs were in the centre of the cross-section.

The adult *C. oryzæ* used in the experiments were bred at 30° C. in wheat of 14 per cent. moisture content and were two weeks old when the experiment started. The wheat used was of medium hardness and contained from 12 to 13 per cent. moisture. In the five main experiments the insects were introduced into the bins as follows :

(1) Evenly throughout the bin at a density of one insect in 50 grains (60,000 insects were used).
(2) Evenly throughout the bin at a density of one insect in 500 grains (6,000 insects were used).
(3) In the top six inches at a density of one insect in 50 grains (6,000 insects).
(4) In the bottom six inches at a density of one insect in 50 grains (6,000 insects).

The insects were introduced at the time the bins were being filled with wheat.

The bins of wheat were kept in a room in which the temperature was maintained at 28° C., the air in the room being circulated by a fan near the roof. The temperature of the wheat at the four depths was measured every day. The distribution of insects was sampled ten days after the experiment had been started and then at various intervals for three or more months. The special sampling instrument* used consisted of two steel cylinders closely fitting inside one another, each fitted with handles. They were 5 ft. long and the inner diameter of the outer tube was $1\frac{1}{4}$ in. Each cylinder had a longitudinal opening $\frac{3}{4}$ in. wide and the inner cylinder was divided into compartments 3 in. long by steel discs. To obtain a sample the sampler was pushed into the wheat to a depth of 5 ft. with the opening of the inner cylinder covered by the outer cylinder. The openings are then made to coincide by turning the handles ; wheat then falls into the compartments ; these are then closed by twisting the outer cylinder a further 180° before the instrument is withdrawn. Each sample, being the contents of a compartment, contained about 700 grains. The bins were sampled in three positions at equal distances from one another, thus providing three replicates for each depth.

Each treatment was duplicated except No. 1, i.e. insects initially distributed evenly throughout at a density of 1 in 50. The duplicates were not carried out at the same time. They are referred to as A and B.

Treatment No. 3 was repeated in a larger metal bin to determine whether the movements of the insects were affected by the size of the bin used. The bin was 2 ft. in diameter and 5 ft. high and a capacity of 19 bushels.

* I am indebted to Mr. F. Wilson of the C.S.I.R. Division of Economic Entomology for the design of this instrument and to the C.S.I.R. Division of Aeronautics for its construction.

## Experimental Results.

The results of the sampling (Table 1) are considered below in relation to the temperature records for each treatment. The interpretations are based on the transformed scale (log $1000+x$), since it is in this scale that significant differences may be calculated. The figures in Table 1 are the geometric means of the transformed values less 1000. When the values are taken to the nearest integer, the geometric means, in nearly every case, are identical with the arithmetic means in the original scale. It was found in most cases that the temperature of the wheat began to rise within the first two or three weeks. The detailed daily temperature readings are not

TABLE 1.

*Showing the Mean Number of Living C. oryzæ in 700 Grains of Wheat at Various Depths in Experimental Bulks of Wheat.*

| Initial Infestation. | Uniform (Heavy) (1A). | | | Uniform (Light) (2A). | | | | Top (3A). | | | | Bottom (4A). | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days / Depth in ins. | 10 | 18 | 28 | 10 | 29 | 39 | 81 | 10 | 28 | 39 | 66 | 10 | 28 | 35 | 51 | 122 | 133 |
| 0– 3 .. | 8 | 10 | 7 | 0 | 1 | 1 | 15 | 2 | 0 | 20 | 49 | 0 | 0 | 0 | 0 | 4 | 11 |
| 6– 9 .. | 28 | 10 | 1 | 2 | 1 | 1 | 0 | 10 | 1 | 1 | 11 | 1 | 0 | 0 | 0 | 6 | 6 |
| 12–15 .. | 22 | 8 | 0 | 3 | 0 | 0 | 0 | 4 | 0 | 3 | 6 | 1 | 1 | 1 | 1 | 10 | 3 |
| 18–21 .. | 17 | 1 | 0 | 1 | 1 | 6 | 0 | 5 | 1 | 9 | 8 | 0 | 0 | 0 | 0 | 5 | 4 |
| 24–27 .. | 17 | 1 | 0 | 1 | 0 | 6 | 1 | 2 | 1 | 2 | 8 | 0 | 0 | 0 | 0 | 11 | 1 |
| 30–33 .. | 17 | 2 | 0 | 2 | 1 | 4 | 0 | 0 | 3 | 3 | 14 | 0 | 0 | 0 | 0 | 6 | 0 |
| 36–39 .. | 24 | 0 | 0 | 2 | 1 | 4 | 0 | 0 | 2 | 1 | 19 | 1 | 1 | 1 | 3 | 3 | 0 |
| 42–45 .. | 14 | 2 | 0 | 1 | 2 | 3 | 0 | 0 | 1 | 1 | — | 1 | 1 | 1 | 9 | 0 | 2 |
| 48–51 .. | 18 | 4 | 0 | 2 | 2 | 5 | 0 | 0 | 0 | 0 | 13 | 6 | 1 | 1 | 32 | 2 | 5 |
| 54–57 .. | 32 | 10 | 2 | 2 | 2 | 6 | 0 | 0 | 1 | 0 | 15 | 4 | 1 | 0 | — | — | — |

| Initial Infestation. | Uniform (Light) (1B). | | | Top (Large Bin) (3C). | | | | | Top (3B). | | | | Bottom (4B). | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days / Depth in ins. | 10 | 28 | 60 | 11 | 28 | 60 | 4 Mths. | 8 Mths. | 12 | 28 | 35 | 65 | 12 | 28 | 35 | 65 |
| 0– 3 .. | 0 | 1 | 4 | 0 | 0 | 3 | 107 | 142 | 2 | 1 | 2 | 7 | 0 | 0 | 1 | 1 |
| 6– 9 .. | 2 | 1 | 2 | 2 | 0 | 3 | 68 | 39 | 4 | 0 | 4 | 33 | 1 | 1 | 1 | 8 |
| 12–15 .. | 3 | 1 | 2 | 1 | 1 | 2 | 6 | 24 | 2 | 1 | 4 | 4 | 0 | 0 | 1 | 4 |
| 18–21 .. | 3 | 3 | 5 | 1 | 1 | 0 | 4 | 7 | 2 | 0 | 6 | 1 | 0 | 1 | 2 | 1 |
| 24–27 .. | 3 | 10 | 5 | 2 | 0 | 0 | 12 | 2 | 2 | 0 | 10 | 2 | 0 | 1 | 3 | 1 |
| 30–33 .. | 4 | 7 | 5 | 1 | 0 | 1 | 6 | 0 | 3 | 0 | 6 | 1 | 1 | 6 | 5 | 2 |
| 36–39 .. | 5 | 6 | 4 | 1 | 0 | 2 | 11 | 0 | 2 | 0 | 8 | 4 | 0 | 2 | 6 | 2 |
| 42–45 .. | 3 | 8 | 3 | 0 | 0 | 0 | 11 | 2 | 2 | 1 | 7 | 2 | 1 | 2 | 10 | 1 |
| 48–51 .. | 5 | 9 | 2 | 1 | 2 | 1 | 6 | 0 | 1 | 0 | 3 | 4 | 4 | 0 | 15 | 1 |
| 54–57 .. | 4 | 10 | 2 | 0 | 1 | 1 | 4 | 0 | 2 | 1 | 4 | 8 | 7 | 1 | 15 | 1 |

Each figure is the geometric mean of three samples each containing 700 grains of wheat. At P=0·01 a significant difference of log $(x+1000)=0·003$.

given, but the smoothed temperature curves for one treatment of experiments Nos. 1, 3 and 4 are shown in Figure 1. The temperature trends in the duplicate experiments were similar.

(1) *Initial infestation evenly distributed at a density of one insect in* 50 *grains.*

The insects remained evenly distributed throughout the bulk until the 18th day. By then the temperature of the wheat had risen throughout, being highest (35° C.) in the middle two feet of the bin (Fig. 1B). The insects by then had been driven to the top and the bottom of the bin. (35° C. exceeds by about 3° C. the highest temperature at which *C. oryzæ* can complete its development from egg to adult.)[1]

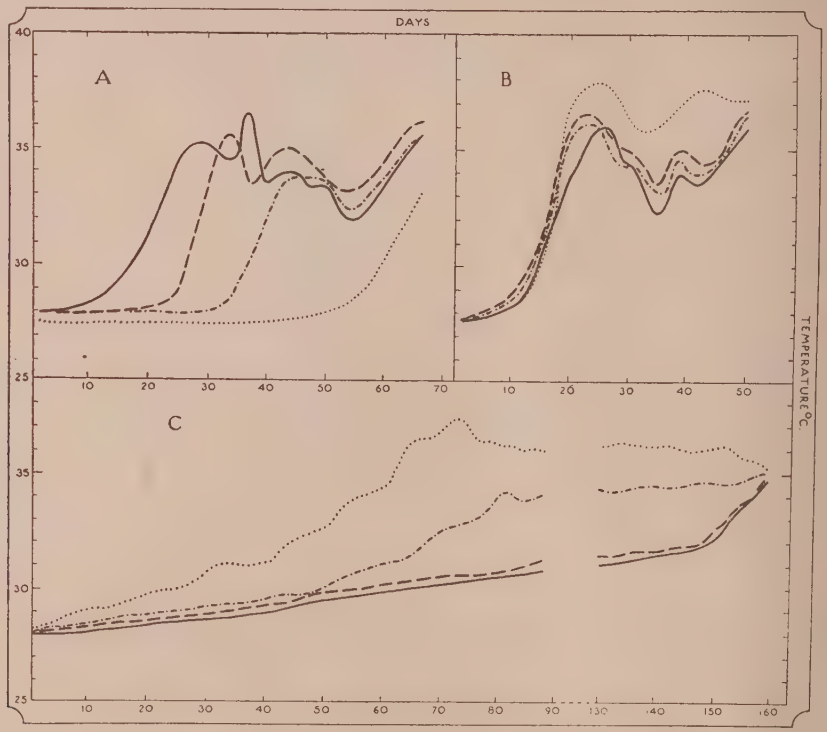


*Figure* 1.

Showing trend of temperature at four depths in experimental bulks of wheat infested by *C. oryzæ.*

A. Initial infestation on the top. (Treatment 3A.)
B. Initial infestation even throughout the bulk. (Treatment 1A).
C. Initial infestation on the bottom. (Treatment 4A.)

Complete line : 1 foot from the top of the bin.
Broken line : 2 feet from the top of the bin.
Dot-dash line : 3 feet from the top of the bin.
Dotted line : 4 feet from the top of the bin.

The temperature of the bulk continued to rise, reaching 39° C. at 1 ft. from the bottom at the end of a month. Most of the living insects were then concentrated in the top nine inches where the temperature was lowest.

The wheat was coolest on the surface where the loss of heat was the greatest. Elsewhere in the bulk the insects were nearly all dead. In this wheat the temperature was too high for a second generation to emerge.

(2) *Initial infestation evenly distributed at a density of one insect in* 500 *grains.*

2A. The insects remained evenly distributed throughout the bulk until the end of the first month. The temperature did not begin to rise until the 24th day, when the temperature was 32° C. in the middle two feet and 30° C. in the rest of the bulk. The temperature curves are not shown as they followed much the same trend as in 1A except that the rate of increase was slower. The middle two feet reached the maximum temperature of 36° C. on the 30th day, and by the 39th day the second generation had emerged, raising the density through the bulk, excepting at the top 15 in., where the temperature was 30° C. Evidently the second generation had not emerged in the top 15 in. at this stage. The temperature rose throughout the bulk to 35-37° C. and these temperatures were maintained to the 80th day, when the experiment was terminated. By then all the living insects were concentrated in the top 3 in., the only part of the bulk at a temperature low enough for the insects to survive.

2B. In the duplicate experiment the results were similar. When the second generation first emerged the density was doubled throughout excepting at the top foot, where, as before, the wheat was cooler—but later on this became infested to a density the same as that in the rest of the bulk.

(3) *Initial infestation in top six inches of bulk at density of one insect in* 50 *grains.*

3A. On the 10th day the insects were still most numerous in the top six inches but some had penetrated to a depth of 2 ft. The temperature of the top foot began to rise on the 18th day and rose to 36° C. at the end of the month (Fig. 1A). By then the high temperature had driven the insects away from the top and some had reached the bottom of the bin. By the 39th day at all depths except that at the bottom foot the temperature was 32° C. or higher. Figure 1A shows how the temperatures were highest near the top thermometer at a depth of 1 ft. The only cool wheat was now on the top 3 in., where heat loss to the air was the most rapid. At the end of two months the infestation was chiefly on the surface, with a minor infestation still on the bottom, where the temperature was still only 32° C.

3B. In the duplicate experiment the insects had reached the bottom of the bin by the twelfth day. The temperatures throughout the bulk had reached 35° C. at the end of the first month, and the final picture was much the same as in 3A, with the infestation eventually confined to the cooler surface few inches.

3C. In the experiment using the larger bin of 19-bushel capacity in which the insects were introduced at the top, the insects reached the bottom in about the same time as they did in the smaller bin. However, the temperatures at each depth rose more rapidly, especially at the surface foot. Most of the wheat was at a temperature of 37° C. at the end of the first month. The temperature was maintained between 34°-37° C. during the second month, at the end of which the infestation was concentrated on the surface. The temperature of the room was then allowed to drop from 28° C. to the prevailing outside air temperature of 15°-18° C. As the bin cooled down the infestation started to develop again throughout the bulk—eventually raising the temperatures again so that at the end of four months the infestation, which was now very dense, was again confined to the surface. The metal sides of the bin had " scalded " wheat clinging to the surface over most of the depth.

(4) *Initial infestation in bottom six inches of bulk at a density of one insect in* 50 *grains.*

4A. By the end of a month there had been little movement of the insects towards the surface. The temperature remained constant until the 36th day, when the bottom foot began to heat up, while the rest of the bulk remained at room temperature (Fig. 1C). There were now as many dead insects at the bottom as there were living

ones. The second generation also remained concentrated on the bottom. The temperature of the rest of the wheat began to rise about the 72nd day, when the bottom foot was at 38° C., and the insects were then driven to the surface. On the 133rd day the temperatures throughout the wheat were over 34° C., except on the surface few inches, where the infestation was now densest.

4B. The duplicate experiment gave similar results. Some insects had reached the surface at the end of the month—but the second generation was again concentrated on the bottom. By the 65th day they were mostly nearer the surface—the temperature of the bulk being 35° C. or more except at the surface few inches.

## Discussion.

In experimental bulks of wheat 5 ft. deep and 1 ft. square in cross-section, at a temperature of 28° C., adult *C. oryzæ* moved very little from the point at which they were initially introduced into the bulk of wheat. This applied whether the point of entry was at the top, the bottom or all over the bulk. Marked movements took place only after the temperature had become uncomfortably high for the insects (i.e., above 32° C.). An increase in temperature was observed with every treatment ; in each case the temperature began to rise first at the seat of the initial infestation. The temperature throughout the wheat eventually rose to 34°-38° C. independent of the position of the initial infestation. In all cases the infestation was finally confined in the main to the surface few inches. The wheat on the surface was coolest ; being the least insulated, loss of heat to the air was most rapid there. The bins which were slowest to heat up were those in which the initial infestation was on the bottom. The multiplication of the insects was also slowest in these cases.

Under the conditions of the experiments described, it is evident that *C. oryzæ* can live and multiply at a depth of 5 ft. in a bulk of wheat until the temperature eventually becomes too high for further multiplication. In these experiments the " heating " of the wheat was due to the metabolism of the insects introduced.

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# The Heating of Wheat Stored in Bulk in Australia

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During the war, when vast quantities of wheat had to be stored for unusually long periods, the wheat handling system in Australia was modified to become a wheat storage system. In many bins and bulkheads where wheat was stored loose, a marked increase in temperature was observed. This occurred throughout the mass of wheat in many cases. At Rickeys, a railway siding in Western Australia, for example, a 20,000 bushel bulkhead of wheat of about 12 per cent. moisture content, heated up throughout its total depth of 16 ft.; eight weeks after the bin had been filled the temperature of wheat ranged from 31° C. to 38° C.* One year after the bin had been filled the temperature of the wheat throughout most of the stack was above 40° C. This is above the maximum temperature at which either *Calandra oryzæ* or *Rhizopertha dominica* can multiply.[2] The coolest wheat was on the surface, where the loss of heat was the greatest, and this was about the only part of the bulk where the temperatures were low enough for these insects to multiply. At the end of the second year the temperatures at some parts on the floor of the bulk were as high as 51° C. At this stage the bulkhead was emptied, enabling an examination of the wheat to be made throughout its depth. Severe damage to the wheat by insects was confined to four or five inches all over the surface and to several inches depth on the floor. Most of the wheat was undamaged, but some was spoilt by "scalding", a term referring to a darkening in colour of the grain with accompanying loss of quality as a result of prolonged subjection to high temperatures.[7] What happened to the wheat in this bulkhead at Rickeys was typical of many bulks of wheat of both small and large capacity (i.e., 20,000 bushels to some millions of bushels). In all cases a relatively small proportion of the grain was badly damaged.

With the aid of appropriate formulæ, it is possible to calculate the rate of heat production throughout the bulk which is necessary to produce the changes in temperature observed.

## Rate of Heat Production.

If the bulk of wheat be regarded as a semi-infinite slab (i.e., a slab extending to infinity in the two horizontal dimensions), the temperature at any depth after equilibrium is reached, when the wheat is heating uniformly throughout, is given by[1]

$$\theta = R\frac{(d^2 - x^2)}{2k}$$

where $\theta$ = temperature × ft. from the centre
R = rate of heat production. B.T.U./ft.$^3$/hr.
2 d = depth of bulk (ft.).
k = thermal conductivity (B.T.U./hr./ft.$^2$/ft.1° F./.

In the case of a mass of wheat which is heating due to the metabolism of insects or other living organisms, the death point of the organisms may be reached before the equilibrium temperature. It is therefore necessary to be able to calculate the

* For the information concerning this and other bulkheads in Western Australia, I am indebted to Mr. H. E. Braine of Co-operative Bulk Handling Ltd., who gave me access to temperature records, and who organized for me an inspection of bulkheads in Western Australia.

temperature at different depths at any particular time before the equilibrium temperature is reached. This is given by the following formula* :

$$\theta=\frac{R}{2k}(d^2-x^2)-\frac{R}{2k}\sum_{n=o}^{n=\infty}(-1)^n \cdot \frac{2}{\pi^3}\frac{d^2}{(2n+1)^3} \; e^{\frac{-(2n+1)\pi^2 Kt}{4d^2}} \cdot \cos\frac{(2n+1)\pi x}{2d}$$

where n is an integer

$K=\frac{k}{c.\rho}$

c=specific heat, B.T.U./lb.

$\rho$=density lb./ft.$^3$

t=time (hours).

A value of 0·084 B.T.U./hr./ft.$^2$/ft./1° F. was used for the thermal conductivity of wheat. This is the value obtained by Robertson (unpublished data) and is close to the values given by Oxley[9] for wheat stored in England.

These formulæ assume simpler conditions than those actually operating in a mass of wheat. They are not regarded as providing more than an approximate guide. No account is taken of convection nor has any attempt been made to allow for the insulating effect of the soil beneath the floor of the bulk. The loss of heat is regarded as being the same at the bottom as on the surface. The calculated temperatures are therefore an under-estimate.

The equilibrium temperature is higher the higher the rate of heat production ; but the time for its establishment is independent of the rate of heat production ; this depends on the depth of the wheat.

The rate of heat production necessary to give the increase in temperature observed at the centre of the Rickeys bulkhead after eight months has been calculated with the aid of the above formula. The mean air temperature during the month the bulkhead was filled was 23° C. After eight months the average temperature along the centre ridge was 31° C. at a depth of 2 ft., 35° C. at at a depth of 8 ft. and 38° C. on the bottom. During this period the average outside air temperature was 18° C., so the temperature rise above the environment was 13° C. at 2 ft., 17° C. at 8 ft. and 20° C. on the bottom. Using the above formula it can be shown that for an increase in temperature of 17° C. at the centre, the wheat would need to be heating throughout at the rate of 0·12 B.T.U./ft.$^3$/hr. This rate of heat production could never be maintained by the respiration of wheat of 12 per cent. moisture content (Robertson, unpublished data). Nor is it likely that micro flora could account for it ; these only become important when the wheat has a moisture content of 18 per cent. or more.[5, 6] It is unlikely that the mycelium in the pericarp of wheat recently observed by Oxley and Jones[11] would be a sufficient source of heat.

## Heat Production by Insects.

*Calandra oryzæ* and *Rhizopertha dominica* are common insects in most places in Australia where wheat is stored. These insects are able to breed in wheat of low moisture content. *C. oryzæ* can breed in wheat of 10·5 per cent. moisture content and *R. dominica* can breed in wheat as dry as 9 per cent. moisture content.[2]

Calculations, based on the known respiration rates of these two species,[4] have been made to see what density of infestation might be necessary to produce the observed changes in temperature. Since the respiratory quotient is unity,[8] it is assumed that carbohydrate is being oxidized, so that 3·5 calories would be produced for each milligramme of oxygen consumed. Assuming that the different stages of

* For this formula and for other expressions relating to the heating of wheat, I am indebted to Mr. E. W. Hicks of the C.S.I.R. Division of Food Preservation, Homebush. I also acknowledge the valued advice of Dr. R. N. Robertson on problems of heat conduction. I have made free use of methods which he has developed (unpublished data) for estimating the heat rise in a mass of wheat.

*C. oryzæ* are present in the proportion one-third half-grown larvæ, one-third mature larvæ and one-third adult, the mean rate of oxygen consumption would be 11 mm.$^3$/insect/hour at 23° C. (the mean temperature of the air during the month the bulkhead at Rickeys was filled). The density of insects respiring at this rate which would be necessary to give a rate of heat production of 0·12 B.T.U./ft.$^3$/hr. (cf. above) would be one insect in 1,000 grains. This would be sufficient to give the increase in temperature of 17° C. after eight months observed in the centre of the bulkhead at Rickeys. At an average temperature of 32° C. a density of one insect in 1,600 grains would suffice.

It is, of course, obvious that the density of insects in the wheat would not be the same all the time, as assumed in the above case. At the temperature the wheat entered the bulkhead (23° C.) *C. oryzæ* and *R. dominica* both increase in density 60 times in two months in wheat of 12 per cent. moisture content.[2] With this rate of increase, an initial density of one insect in 300,000 grains would be sufficient to give the temperature rise recorded in eight months. This is still an under-estimate, as no allowance has been made for the fact that as the density increases the temperature rises and the rate of metabolism of the insects increases accordingly. The rate of heat production of larval *C. oryzæ* at 33° C., for example, is twice the rate at 23° C.[4] The maximum temperature at which *C. oryzæ* can multiply and so still produce heat for any length of time is 33° C.; *R. dominica* on the other hand may continue multiplying at 38° C. depending on the moisture content of the wheat.[2]

If the wheat contained only 11 per cent. moisture, the rate of multiplication of both species at 23° C. is about one-third that in wheat of 12 per cent. moisture content, so the initial density required to produce the same increase in temperature would be three times as great. The rate of respiration per insect is not affected by the moisture content of the wheat to any appreciable extent.[4] The relative importance of the two species and their different stages under various conditions can be determined from their rate of multiplication[2] and rate of oxygen consumption.[4] The rate of heat production of a mixture of the different stages of *R. dominica* at 23° C., for example, would be one-fifth that of *C. oryzæ*.

### Calculated Increase in Temperature due to Insects.

In Figure 1 is shown the calculated temperature increase at different times for a bulkhead of 16 ft. depth (like that at Rickeys) when mixed stages of *C. oryzæ* are present at an average density of one insect in 2,000 grains, the temperature at which the insects are respiring being 23° C. The equilibrium temperature is 13° C. (23° F.) above the original temperature of the wheat and is reached in 30 months. The curves show the extent to which the temperature falls off as the distance from the centre of the bulk is increased.

The effect of the depth of the bulkhead on the rate of temperature increase expected with the above density of one *C. oryzæ* in 2,000 grains is illustrated in Figure 2. The depth of the largest bulkhead in Australia was about 60 ft. In the first six months there is little difference in the temperature at the centre of a 16 ft. and a 60 ft. bulk. After the first six months the temperature of the deeper bulk rises much more rapidly. The equilibrium temperature of the 60 ft. bulkhead is of theoretical interest only, being 180° C. above the original temperature of the wheat and taking 50 years to be reached.

The striking fact about these figures is the very low numbers of insects required to cause heating of wheat. The numbers are so low that such wheat would probably be classed as free from insects by most observers. This means that wheat may heat to the lethal point with only a negligible proportion of the grains showing damage. The grain then becomes free from living insects and is unlikely to become re-infested. The only parts of the bin where the temperature is sufficiently low for the insects to survive is on the surfaces and sides. Experience during the war years has shown that such damage is generally confined to a few inches near the surface.

It has been shown[3] that insects do not move readily in bulk wheat until the temperature becomes uncomfortably high for them. This means that insects present in various depths of the wheat tend to stay there until the heat generated by their own metabolism drives them away. The restriction of the insects to the surface is not to be explained on the basis of any initial mass movement to the surface, for this does not occur ; but it is due to the development of temperatures on the depth of the wheat which are lethal to the insects there. The surface wheat is both cooler and moister by virtue of being next to the outside air. The experiments in small bulks already referred to[3] substantiate this view.

The maintenance of the high temperatures throughout the bulk for long periods (a year or so) after the insects there are all dead must be due partly to the low thermal conductivity of the wheat. And all the time there is a layer of insects present on the surface at a high density, producing heat at a rapid rate, and so helping to prevent heat loss over this area.

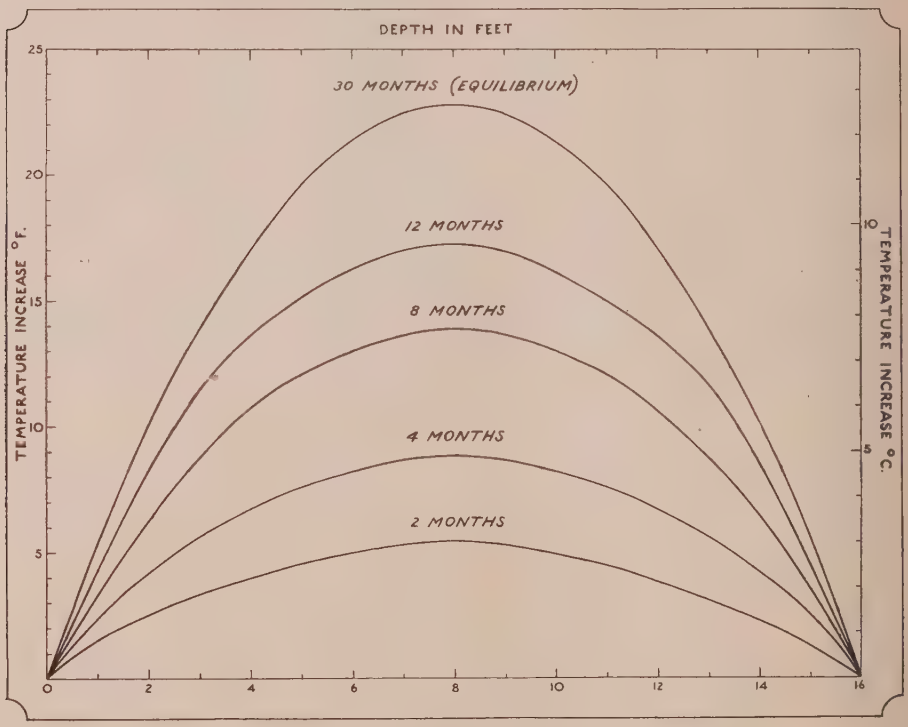


*Figure* 1.

Showing calculated temperature increase at different times for a bulkhead of wheat 16 feet deep, when *Calandra oryzæ* were assumed to be present at an average density of 1 insect in 2,000 grains.

## Practical Considerations.

This raises the question whether bulk wheat could be completely protected from insect damage by adequate insulation of surfaces. Several inches of sawdust on the surface would probably be sufficient. It would be desirable, however, to have this layer separated by some means from the rest of the wheat, by a canvas for example, otherwise it would be impossible to prevent it from mixing with the wheat during the emptying of the bulkhead. Wheat might even be used for this insulation ; it has

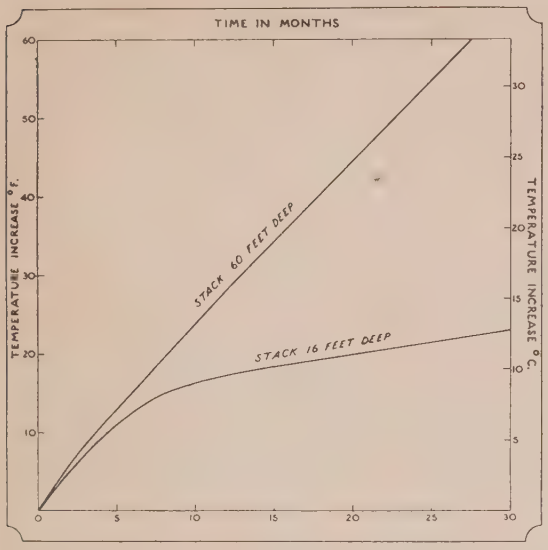


*Figure 2.*

Showing the calculated temperature increase in two bulkheads of wheat. One is 16 feet deep, the other 60 feet deep. It was assumed that *Calandra oryzæ* was present at the rate of 1 insect in 2,000 grains of wheat.

about the same insulating properties as sawdust, but would have the disadvantage of becoming infested. Some experiments in the use of insulated walls have already been made by Co-operative Bulk Handling Ltd. in Western Australia, in their case with the object of preventing sudden temperature changes and consequent condensation of water vapour on the inside walls next to the wheat. From the above investigations it would also seem that wheat which is infested with insects would be most safely shipped abroad in bulk rather than in bags.

The phenomenon of wheat which has a moisture content lower than 15 per cent. heating is not confined to Australia. During the war cases were also reported in England.[8] Oxley and Howe[10] consider that insects were responsible for the heating in these cases too.

## Acknowledgments.

The author acknowledges his indebtedness to Mr. H. G. Andrewartha, who suggested the investigation and whose guidance was given throughout. The assistance of Dr. R. N. Robertson and Mr. E. W. Hicks in problems of heat conduction and the cooperation of Mr. H. E. Braine of Co-operative Bulk Handling Ltd. in Western Australia, are gratefully acknowledged.

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# Responses of Herbage Legumes to Applied Nutrients on some Southern Australian Soils and their Dependence on External Factors

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The low fertility of the lands adjacent to the coastline of southern Australia has prompted investigation of soil improvement based on the use of appropriate herbage legumes and the mineral supplements required. In South Australia, soils dominated by red gum (*Eucalyptus camaldulensis*) and peppermint (*E. odorata*) have, for the most part, needed only soluble phosphate to bring about a sufficient accumulation of nitrogen and organic matter ; but the evidence of the past ten years has indicated that most land in that State receiving high rainfall and characterized by stunted vegetation, ranging from depauperate scrub to heath, is deficient also in additional essential mineral nutrients.

The need to explore soil fertility problems in a broad regional sense led the authors to test the method of small pot cultures in 1942. A high degree of freedom from contamination, together with the control and speed attained, enabled a useful picture of the probable widespread incidence of complex deficiencies to be secured fairly rapidly.[4]

The tests of the past two years have both confirmed the value of the method and resulted in the accumulation of new knowledge.

## Technique.

The use of a small glazed earthenware pot was first suggested by the earlier work of Strong and Trumble[16] on the excretion of nitrogen from herbage legumes. Growth was vigorous in enamelled pots of 4 Kg. capacity, but poor in glazed earthenware pots of 1 Kg. capacity. The latter was considered at the time to be due to the smallness of the pot, but is now known to have resulted from zinc deficiency. Uniformly good results with legumes in enamelled pots of varying sizes have been due in part to mineral contamination from the enamel.[17] The earthenware pots, because of their incapacity to provide nutrients to the medium, are well suited to the biological assay of soil deficiencies.

The increased number of tests made possible by the small size of the pot is another factor. Soil has been taken from sufficient samples to represent the top four inches of the area being investigated. The studies of the soil to this depth govern the early development of the seedling, which frequently determines its success or failure. This is essentially a first step in a more comprehensive study, which may reveal whether minerals lacking in the top four inches can be absorbed from lower depths.

For collection, new bags free from contamination have been employed ; the soil was mixed with a non-metal spade on a cement floor, and passed through a sieve coated with clear dulux. No mulch has been provided over the surfaces of the pots and the purest reagents obtainable have been applied. Ordinary distilled water has been used except for a limited number of tests in which double distilled water was substituted to permit the detection of copper deficiency where this was necessary. The distilled water employed contained 0·1 mgm. copper per litre,* resulting in a cumulative application of the order of 14 lb. copper sulphate per acre over a full

* From information supplied by Dr. C. S. Piper.

growth period of twelve weeks with average yields. A check has been maintained in the field on the possible role of copper at centres where this was likely to be concerned.

The form and rate of the nutrients added have followed as closely as possible field practice, provided this was consistent with minimum contamination. Rates have been calculated on an area basis. Zinc as zinc sulphate was applied at the rate of 7-14 lb. per acre and molybdenum as sodium molybdate or ammonium molybdate at the rate of 2 oz. per acre. In the case of molybdenum it has been shown[2] that these two forms and molybdenum trioxide give comparable results in the field; but the trioxide, owing to its more finely divided condition, which is an advantage in mixing, its decreased susceptibility to surface washing and the readiness of its preparation by roasting the raw sulphide (molybdenite), has been used in commercial application. In the pot cultures the molybdates were more appropriate for reasons of purity. Potassium has been applied as potassium sulphate, in most cases at 56 lb. per acre; manganese as the sulphate at 4-14 lb. per acre; boron as boric acid at $\frac{1}{2}$-1 lb. per acre; magnesium as the sulphate at widely varying rates; iron as the sulphate at 7-14 lb. per acre and vanadium as the sulphate at 1 lb. per acre. A basal dressing of phosphate has been employed throughout, but owing to the likelihood of contamination resulting from the use of commercial superphosphate, pure monocalcic phosphate was used in the earlier tests. As the war progressed and this reagent became unobtainable it was replaced by a mixture of sodium di-hydrogen phosphate and calcium chloride.

## Place of the Method.

The investigation of soil fertility problems has been assisted by the use of pot cultures since 1757, when the method was introduced by Home[7] to afford a degree of control not possible in the field and to enable specific factors of nutrition to be examined with precision and in relation to other variables. Some criticism of the pot culture approach has been based on the self-evident fact that the artificial culture does not emulate the more or less natural condition of the field; for this very reason, however, it can be especially informative. Provided it is employed with sufficient understanding and discrimination, the role of specific nutrients or groups of nutrients can be defined, where often such would be impossible under field conditions. No better example of its function in this regard can be given than the work of Hellriegel and Wilfarth[5] on the nitrogen nutrition of leguminous plants.

The main object of the present studies was to provide a rapid lead from which the subsequent field exploration could be directed with greater expedition and certainty. The work was conducted wherever possible with reference to the field. In a total of approximately two hundred tests carried out over four years, no lead was given which was subsequently proved false by field experience.

The method has had greatest value in regard to molybdenum deficiency; the molybdenum trioxide in commercial use drifts considerably in the field,[2] either from wind movement during application, from washing down the slope following treatment, or as the result of rain splash combined with wind movement during wet gusty weather. These factors have made the investigation of molybdenum in relatively small field plots extremely difficult; but the isolation of individually treated samples, made possible by the pot culture technique, has proved a definite advantage. This advantage may now be illustrated.

In soils from two centres, Mt. Compass and Waitpinga, situated in the southern districts of the Mt. Lofty Ranges in South Australia, responses to molybdenum were obtained as shown in Table 1.

Field tests in small plots conducted at Waitpinga in 1942-44[3] failed to show any benefit from molybdenum; there had been a suggestion earlier that copper might be required.[18] The pot culture results naturally do not preclude the possibility that copper might be needed in addition to molybdenum, for the reasons given earlier.

Increases with copper, which became greater as the phosphate status improved, were evident in field plots in 1944.[3] Strip tests made with a drill in 1944 across a paddock of the property concerned showed that both molybdenum and copper were involved, there being a striking interaction between the two micronutrients. Field confirmation on a practical commercial scale accumulated in both 1944 and 1945; evidence from field plots that molybdenum was needed did not arise until 1945. In 1945 a yield of 33·95 cwt. dry matter/ac. was obtained, following a dressing of 1 oz./ac. molybdenum in 1943, compared with 16·93 cwt. where no molybdenum was added.* By this time the area of land treated to obvious advantage in this district covered some thousands of acres.

TABLE 1.

*Tests of Two Soils Receiving a Basal Dressing of $NaH_2PO_4$ With and Without Ammonium Molybdate at 2 oz./ac.*

| Centre. | Year of Test. | Test Plant. | Mean Dry Weight per Pot. (Gms.) | | Significant Difference. (P=0·01) |
|---|---|---|---|---|---|
| | | | Control. | Mo Added. | |
| Mt. Compass .. | 1943 | Mt. Barker subterranean clover. | (Means of 32 pots) 2·22 | 2·84 | 0·10 |
| Waitpinga .. | 1943 | Palestine strawberry clover. | (Means of 16 pots) 0·86 | 2·29 | 0·20 |

At Mt. Compass no definite evidence of response to molybdenum was secured from field plots until 1945. Dressings on a commercial scale in 1944 and 1945, following the pot culture evidence of 1943, gave striking evidence of response on pastures that had been declining badly for several years despite liberal dressings of phosphate.

In a previous communication,[4] evidence was presented of response to a *terra rossa* soil from Mt. Benson, South Australia, to copper, zinc and potash, the evidence being derived from a preliminary test with groups in 1942, followed by a more searching test with individual elements in 1943. The results of field tests conducted at this centre over the seasons 1942-45 were that responses to copper were obtained and that there was evidence also that zinc and potash are likely to be required.[3]

## Minerals Concerned.

At the commencement of the work, evidence from various sources had revealed deficiencies of copper over an extensive region of the mainland of South Australia[10]† and on Kangaroo Island,[15] deficiency of zinc along the Murray River and at Beetaloo Valley,[14] at Robe[10] and in the flax growing districts, both north and south of Adelaide,[8] and deficiency of molybdenum at both Meadows and Houghton.[1] It was desired fairly expeditiously to enquire as to the extent to which deficiencies of these or other nutrients might prove responsible for numerous practical failures of pasture establishment in different parts of South Australia.

The minerals applied were arranged in the groups Cu Zn; K Mn B; Mo Fe Mg V. Responses to all groups were secured once the technique was standardized and almost every soil tested has given significantly improved growth

* Mr. C. A. N. Smith, private communication, April, 1946.

† A second paper[11] was prepared by Riceman and Anderson in 1941 but did not appear until 1943, when it came to the authors' notice for the first time.

of subterranean clover with one or more of these groups. So far as the elements within the groups are concerned, zinc and molybdenum have proved to be the main effective nutrients in the first and third groups respectively, as indicated by an improved growth of subterranean clover in its early developmental stages. Responses to the K Mn B group were common; these proved in most cases to be due to K. Comparatively few responses to Mn and B were recorded. Negative interactions between Mn and other nutrients have proved fairly common.

### Location of Responses.

The method has been applied for the most part to the poor soils of the higher rainfall areas, many of which are sands or light textured soils generally. Parallel with the pot culture programme has proceeded extensive field observation backed by a limited number of field experiments and a questionnaire in the case of molybdenum.

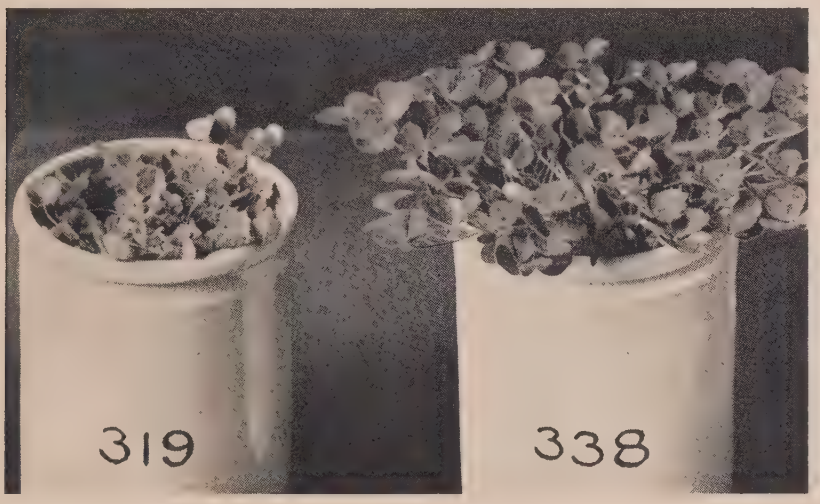


*Figure* 1.

Response of subterranean clover to molybdenum on a podsolized soil from Tooperang in the Mt. Lofty Ranges, south of Adelaide. Basal phosphate applied; L.=control, R.=molybdenum added.

Responses to molybdenum have been recorded largely in the Mt. Lofty Ranges, from Angaston to Cape Jervis; in the Clare district, on Eyre Peninsula and at a few centres in the south-east, especially towards the Victorian border and into Victoria. The soils are, for the most part, podsols or allied types derived from quartzites, shales and laterites, frequently on elevated slopes and almost invariably with pH below 7. The zone in which molybdenum has given a definite response is, in fact, that best adapted to subterranean clover. Marked increases were also obtained on soils within this category from Woodend (Vic.) and Narrabri (N.S.W.). Responses to molybdenum have proved to be much less affected by seasonal changes than responses to zinc. Molybdenum deficient plants show a reduction of green pigmentation and a characteristic stunting.

Deficiencies of zinc appear over an extensive region and the tests have indicated that it would be difficult to define an area in the agricultural regions of South Australia where zinc might not prove beneficial under particular seasonal conditions. Responses

to zinc have been obtained on both acid and alkaline soils, sands, sandy loams and clay loams. The conditions of light and temperature have been found to govern the degree of response secured (Table 3). Concerning the extensive area of the Ninety Mile Desert, on which field responses to zinc have been obtained from subterranean clover,[9] zinc deficiency was demonstrated in 1943 on the basis of samples from Culburra and Bangham Scrub within the region and at Lake Albert and Brinkley, which border it. Zinc-deficient subterranean clover grown in the pot cultures has invariably shown numerous abnormally formed leaves. A factor to be overcome in field work is the influence of particular seasonal conditions on the response to zinc.

Copper has not been well covered by the pot culture tests. There is obviously an extensive area in the south-east of South Australia where the use of copper has now become accepted.[11] Field tests appear to be essential before reliable interpretations can be drawn concerning the use of copper.

Fairly widespread potash deficiency is indicated by the pot tests. This has failed to show formerly, largely because of its dependence on other minerals and especially on molybdenum. Two-thirds of all significant interactions recorded concerned potash; of these more than half are interactions of potash with molybdenum. Most of the remainder involve both potash and zinc. Little attention has so far been paid to potash in the field. Supplies of the salts of this element were scarce during the war and it is possible that associated perennial grasses may be capable of absorbing potash from lower depths and excreting it from the root system, as shown by Richardson, Trumble and Shapter[13] to the surface layers of soil.

The elements copper, zinc, molybdenum and potash have been revealed from these tests as the principal minerals to be investigated under field conditions in South Australia in the future. Manganese and boron appear seldom to increase production. It is possible that additional micronutrients as yet not defined, may have a bearing on the production of herbage legumes.

## Soil Factors.

Apart from the soil type, the effectiveness of burning, ploughing and cultivation in particular relation to the amount of ash conserved following the burn, an absence of regrowth and suitable conditions of tilth are obviously important. It has been considered that the use of certain conditioning crops such as peas, turnips and oats might improve the subsequent development of clover. Tests carried out in 1944 and summarized in Table 2 show that the yield of clover following fallow was much greater than that following peas, which in turn exceeded that following oats, at three levels of phosphate. The response to a mineral group containing Cu Zn K Mn B Mo was comparable under all three methods of preparation.

A further experiment was carried out in which the peas were returned to the soil, but the clover produced on the fallowed soil was still greater in this case than following peas turned in. Barley sown following the peas and subterranean clover produced 0·68 gm. per pot, compared with 0·59 gm. after fallow and subterranean clover. The gramineous plant thus gained from the peas-clover sequence compared with the fallow-clover sequence, altogether the clover was better after the fallow than after the peas.

## Climatic Factors.

The climatic factors concerned are those of moisture, temperature and light. Moisture levels varying from 40 per cent. to 90 per cent. of the full capacity of the soil to hold moisture and including alternations of these extremes had no effect on the response secured.

It had been observed for some years that where no minerals were added plants grown in early autumn or late spring produced much higher yields than those grown in the winter months. The former did not respond well to treatment, particularly

with zinc, so that it became necessary to conduct the majority of the tests between late autumn and early spring. It was at first considered that the higher soil temperature resulted in a greater availability of zinc in the soil, but when zinc-deficient soil

TABLE 2.

*Effect of Oats and Peas as Conditioning Crops, Compared with Fallow on the Yield of Mt. Barker Subterranean Clover, With and Without the Application of a Mineral Group.*

(Yield of subterranean clover in gm. dry matter per culture, May-June, 1944, after treatment in February-April, 1944, as under—means of two cultures.)

| Treatment (February-April, 1944). | Oats. | Peas. | Fallow. |
|---|---|---|---|
| Yield of clover (May-July, 1944)— | | | |
| $P_3+E_0$ .. .. .. .. | 0·63 | 1·02 | 1·63 |
| $+E_1$ .. .. .. .. | 2·23 | 2·26 | 3·47 |
| $P_6+E_0$ .. .. .. .. | 0·49 | 0·91 | 1·56 |
| $+E_1$ .. .. .. .. | 2·26 | 2·58 | 3·48 |
| $P_9+E_0$ .. .. .. .. | 0·61 | 1·01 | 1·30 |
| $+E_1$ .. .. .. .. | 2·41 | 2·81 | 3·22 |
| Mean of all phosphate $+E_0$ .. | 0·58 | 0·98 | 1·49 |
| $+E_1$ .. | 2·30 | 2·55 | 3·39 |
| Mean .. .. .. | 1·44 | 1·76 | 2·44 |

$P_3$, $P_6$, $P_9$=superphosphate at 3, 6, 9 cwt. per ac. respectively.
$E=Cu_2Zn_{10}K_{56}Mn_{10}B_1Mo_{.05}$. (Subscripts refer to rates in lb. per acre.)
Sig. diff. (P=0·01): Means of 2=0·53, of 6=0·36, of 12=0·25.

was treated for one week in a moist condition at temperatures ranging from 60° F. to 100° F., it was found that no modification of the growth of the clover or its response to zinc was secured (Table 3).

TABLE 3.

*Effect of Temperature on Response of Subterranean Clover to Zinc.*

Treatment of moist soil for one week at varying temperatures prior to seeding+mineral treatments, subterranean clover (May-August, 1944).
Means of three replicates. (Gm. per culture.)

| Temperature Treatments. | 60° F. | 70° F. | 80° F. | 90° F. | 100° F. | Mean. |
|---|---|---|---|---|---|---|
| (i) Yalkuri soil— | | | | | | |
| Control .. .. | 1·79 | 1·70 | 1·67 | 1·80 | 1·74 | 1·74 |
| Zn added (10 lb. $ZnSo_4$ per acre) | 2·13 | 2·04 | 2·01 | 2·01 | 2·07 | 2·05 |
| Signif. diff. (P=0·01) | | | =0·39 | | | 0·17 |
| (ii) Brinkley soil— | | | | | | |
| Control .. .. | 0·84 | 0·90 | 0·94 | 1·26 | 0·86 | 0·96 |
| Zn added (10 lb. $ZnSo_4$ per acre) | 1·52 | 1·59 | 1·55 | 1·59 | 1·54 | 1·56 |
| Signif. diff. (P=0·01) | | | =0·36 | | | 0·15 |

Heat treatment not significant on either soil. Response to Zn significant on both soils.

The above results indicate that the seasonal effect is more likely to be concerned with the plant than with the soil. To test the influence of varying light duration and temperature on the response to zinc of growing plants of subterranean clover, a further test was conducted, and its results are shown in Table 4.

It is obvious from the above results that light duration may exercise a considerable effect on the plant's capacity to utilize zinc from a relatively unavailable source.

The results obtained are in contrast to those quoted by Hoagland[6] to the effect that citrus trees and tomatoes in California are most liable to zinc deficiency under improved conditions of light and do not normally respond to zinc in the winter months, when subterranean clover under South Australian conditions is most likely to be improved by applications of this element. More detailed work on the light factor is in progress.

TABLE 4.

*Influence of Increased Light duration and Temperature on Response to Zinc.*
Subterranean clover (July-September, 1944).
Means of three replicates. (Gm. per culture.)

| | $L_1H_1$ | $L_2H_1$ | $L_1H_2$ | $L_2H_2$ |
|---|---|---|---|---|
| $Zn_0$ .. .. .. | 1·06 | 1·76 | 1·16 | 1·34 |
| $Zn_{10}$ .. .. .. | 1·63 | 1·91 | 1·40 | 1·45 |

$L_1$=normal daylight (10 hours—8 a.m.–6 p.m.).
$L_2$=normal daylight+artificial light for 4 hours.
$H_1$=mean air temperature approximately 55° F.
$H_2$=mean air temperature approximately 70° F.
Signif. diff. (P=0·01)=0·25.
L, H and Zn significant at 1 per cent.
L×Zn, L×H, L×Zn×H significant at 1 per cent.

## Modifying Factors of the Technique.

The size and type of pot employed have been considered. While the use of a pot containing approximately 1 Kg. of soil has enabled larger numbers of cultures to be dealt with, evidence was needed as to the reliability of the differences resulting from treatment compared with those obtained in pots of a larger size. The following table gives the results of a test carried out in the 1945 season in which the standard pot used, averaging approximately $3\frac{1}{2}$ inches internal diameter, was compared with a larger cylindrical pot averaging $4\frac{1}{2}$ inches internal diameter and two types of rectangular containers 6×4 inches. The capacities of these pots varied from 1·2 to 5·0 Kg. Two types of the larger rectangular containers, one of enamelled iron and the other of glass, were employed ; these revealed the extent to which contamination by zinc in the case of the enamelled pot, and some other element—either potassium or an element capable of replacing potassium from the glass jars, were capable of influencing the results obtained (Table 5). The results of this test are also represented graphically in Fig. 2.

It will be seen that the soil has responded to the combination of all three elements in both the $3\frac{1}{2}$-inch and $4\frac{1}{4}$-inch. All four types of pot have shown a significant response to the group of the three elements concerned, but contaminations from the enamelled and glass containers have had a strong influence on the response to zinc and potassium respectively where the remaining elements concerned have not been fully supplied. The response to potash applied singly is thus much higher in the enamelled pots than in the other types owing to the provision of zinc by the enamel. The potash, however, has had a negligible effect in the glass jar except where both zinc and molybdenum have been provided. The element absorbed from the glass was evidently not sufficient for full requirements.

The percentage response to the complete groups of three elements varied from 68 per cent. in the case of the $4\frac{1}{4}$-inch pot, to 129 per cent. in the case of the glass jar. The question of contamination appears to be of greater significance than the

size of the pot. The fact that the smaller sizes have given the smallest degree of response renders the differences secured of even higher significance.

## Responses to Different Legumes.

The type of legume employed is likely materially to govern the degree of response obtained. Different species, and possibly strains, of herbage legumes may differ firstly in their requirements of particular elements, and secondly in their capacity to absorb these from relatively unavailable sources in the soil. The work of Riceman

TABLE 5.

*Responses of Mt. Barker Subterranean Clover to a Mineral Treatment of Lake Albert Soil with Varying Sizes and Types of Pot.*

(August-October, 1945.)

Means of three replicates. (Gm. per culture.)

| Size and Type of Pot. | Capacity (Kg.). | Plants per Culture. | — | Zn | K | Mo | ZnK | ZnMo | KMo | ZnKMo | % Incr. ZnKMo |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3½ in. (int. diam.) glazed earthenware .. .. | 1·2 | 6 | 1·95 | 2·02 | 2·31 | 2·00 | 2·62 | 2·41 | 2·82 | 3·41 | 75 |
| 4¼ in. (int. diam.) glazed earthenware .. .. | 2·1 | 8 | 2·35 | 2·79 | 2·83 | 2·48 | 3·23 | 3·07 | 2·58 | 3·94 | 68 |
| 6 in.×4 in. (int. rect. meas.) enamelled .. .. | 5·0 | 10 | 3·05 | 3·65 | 5·63 | 4·12 | 4·68 | 4·02 | 5·72 | 5·85 | 92 |
| Glass do. .. .. .. | 5·0 | 10 | 2·94 | 4·51 | 3·09 | 3·71 | 4·53 | 4·76 | 3·86 | 6·72 | 129 |

Signif. diff. (P=0·01) (means of 3): 1·09.
(P=0·05): 0·82.

Pots×Zn, Pots×K } Signif. at 1%. Pots×Mo. Signif. at 5%.

and Anderson[10, 11] and of Riceman[9] has already indicated a difference in the response of lucerne, barrel medic and subterranean clover to copper and to zinc. Lucerne appears to be specially dependent on applied copper where the natural status of this element is low, whereas barrel medic and subterranean clover are less

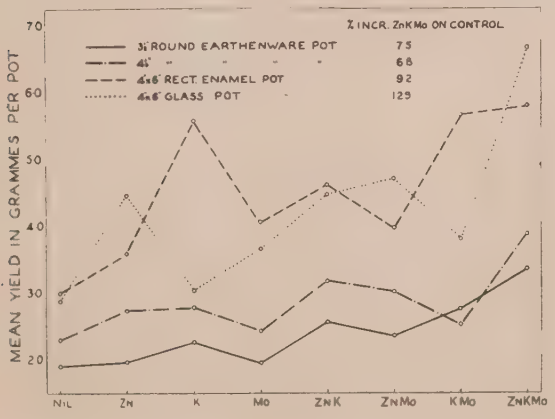


*Figure 2.*

Responses to Zn, K and Mo in all combinations on Lake Albert soil, using four different types of pots.

responsive to copper, but substantially improved by zinc. The following table shows the differential behaviour of peas, lucerne, barrel medic, subterranean clover and strawberry clover to applications of copper, zinc and molybdenum on a soil naturally deficient in all three elements. The comparisons refer only to responses obtained in the initial stages of growth.

In this experiment, sixteen combinations of treatments were applied to five legumes. For brevity the results are expressed as variance ratios, from the statistical analysis, instead of the large number of mean weights recorded; the data are available, however, should they be requested.

It will be seen from the above table that lucerne was the only legume to respond significantly to copper under the conditions of the test, that barrel medic, subterranean clover and strawberry clover all responded actively to zinc and that all five legumes gave particularly good responses to molybdenum.

Each of the above legumes has been employed for different purposes during the course of the work, but all responses should be considered in relation to the legume grown. Because subterranean clover is likely to be the principal herbage legume utilized in the development of the high rainfall areas with acid to neutral soils primarily considered in this work, it has been used as the test legume for the majority of the tests conducted.

TABLE 6.

*Response of Different Legumes to Copper, Zinc and Molybdenum on Soil from Lake Albert known to be Deficient in these Three Elements.*

| Element Applied. | Variance Ratios $\frac{S_1^2}{S_2^2}$ | | | | | Value for Significance at | |
|---|---|---|---|---|---|---|---|
| | Peas. | Lucerne. | Barrel Medic. | Sub. Clover. | Strawberry Clover. | P=0·05. | P=0·01. |
| Copper .. | 0·685 | *5·207* | 2·063 | 0·722 | 0·510 | 4·381 | 8·184 |
| Zinc .. | 0·883 | 0·982 | **28·310** | **15·525** | **15·531** | 3·127 | 5·010 |
| Molybdenum | **11·354** | **45·495** | **14·333** | **27·809** | **82·653** | 4·381 | 8·184 |

Figures printed in italic indicate significant P=0·05.
Figures printed in black indicate significant P=0·01.

## Additional Factors.

All legumes were inoculated with a tested strain of *Rhizobium* prior to seeding.*

In most cases typically healthy nodulation of the legumes resulted, but on certain soils with which a vigorous growth of clover was normally effective, efficient nodulation has not yet been obtained. Nodules are formed, but they are cheesey in appearance with a minimum of bacterial tissue and the hæmoglobin normally present in healthy nodules is absent. Further work on soils with which this difficulty has been experienced is in progress.

The question of contamination so far as the conduct of the glasshouse tests is concerned has already been discussed. To indicate how the use of different forms of commercial superphosphate may govern the results obtained in field work on areas deficient in micronutrients, which may be present as impurities in the fertilizers employed, the following results of an experiment carried out in 1944 with superphosphate from three different sources of phosphate rock are presented. This test was prompted by observation in the field that double dressings of superphosphate with the field drill had given greater responses by subterranean clover on Kangaroo Island than had been observed in earlier years with pre-war superphosphate from a different source.

## Interactions.

The work has revealed that interactions between the different nutrients found to be necessary are common in these soils. In a total of two hundred tests there were thirty significant positive interactions and twenty significant negative interactions

* Acknowledgment is made to Miss M. P. Thomas, Soils Division, C.S.I.R., who prepared the bacterial cultures employed.

of the first order. Sixty-nine per cent. of the interactions on sands and light-textured soils generally were positive; fifty-six per cent. of the interactions on loams were negative.

Of the positive interactions, 66 per cent. concerned potassium and 70 per cent. molybdenum; 40 per cent. of all positive interactions concerned both potassium and molybdenum. All of the potassium × molybdenum interactions, in which additional elements were not concerned, were positive. On the other hand manganese was the principal element involved in the negative interactions. This element occurred

TABLE 7.

*Tests with Mt. Barker Subterranean Clover on Waitpinga Ironstone Soil known to be Deficient in Copper and Molybdenum.*

| Type of Superphosphate. | | Mean Dry Weight per Pot. (Gms.). (Means of 2 Pots.) | | | Means of all Super Levels. (6 Pots.) |
|---|---|---|---|---|---|
| Date of Manufacture. | Source of Rock Used. | Super. 70 lb. $P_2O_5$ p.a. | Super. 140 lb. $P_2O_5$ p.a. | Super. 210 lb. $P_2O_5$ p.a. | |
| Pre-1942 | Ocean Is. .. .. | 1·16 | 1·23 | 1·47 | 1·28 |
| 1942–43 | 75% Egyptian,* 25% Makatea .. .. | 1·73 | 2·14 | 2·19 | 2·02 |
| 1943–44 | 55% Egyptian,* 45% Makatea .. .. | 1·72 | 2·28 | 2·43 | 2·14 |
| | Signif. diff. (P=0·01) | | 0·44 | | 0·25 |

* Following this test it was suggested to the Soils Division, C.S.I.R., that spectro-chemical analysis of the Egyptian superphosphate concerned, which is of much lower grade phosphate content and therefore more likely to contain traces of elements such as molybdenum, would be of considerable interest. A survey of a large number of rock phosphates and superphosphates for the various trace elements present is now in progress and the results will be available shortly.

in 75 per cent. of the negative interactions recorded, 15 per cent. containing boron. The question of these interactions and their significance will be dealt with in a further paper. In the meanwhile, however, attention is drawn to the care needed in interpreting the behaviour of groups of minerals in which both positive and negative interactions may operate. Examples of the six main types of first-order interactions recorded are given in Fig. 3.

## Conditions Necessary for Response.

Many factors are likely to affect practical responses secured in the field. The geological origin of the soil and the type of weathering concerned in soil formation are primary factors, but past history of the land, including manner of clearing, effectiveness of fallowing and extent of cropping practised, together with depletion or accumulation under grazing, will also be concerned.

More clear-cut results have so far been obtained with sands than with loams and clays. Contamination of the fertilizers employed will govern the degree of response to zinc and molybdenum in particular.

Seasonal conditions, especially as they concern the light factor and relating also to temperature, are especially important in regard to zinc. Response to molybdenum on the other hand, has been shown to be relatively independent of seasonal conditions.

The need of herbage legumes for potassium appears to be affected by climatic variations as in the case of zinc; it is also probable that the excretion of available potash from the roots of associated grasses may be a factor. Some evidence has already been obtained to support these statements, and further experiments are in progress.

## General Summary.

1. The importance of soil improvement in the areas of highest rainfall in southern Australia is stressed and the place of a rapid means of exploratory investigation on broad regional lines defined.

2. The technique of the method of small pot cultures employed by the authors over four years is outlined and its value demonstrated.

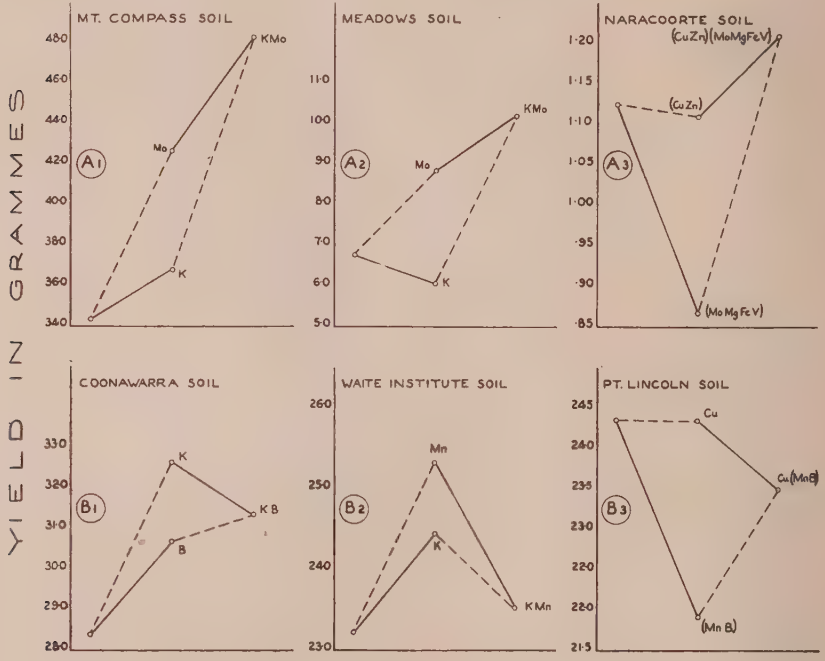


*Figure* 3.
Interaction diagrams representing the following six classes

| | Signif. effect on single group. *a* | *b* | Signif. effect of groups *a*, *b*. | Percentage of all signif. interactions. |
|---|---|---|---|---|
| A (positive interaction 60%) | | | | |
| 1 | + | + | >control *a*, *b* | 22% |
| 2 | + | 0 or − | >control *a*, *b* | 28% |
| 3 | 0 or − | − | >control *a*, *b* | 10% |
| B (negative interaction 40%) | | | | |
| 1 | + | + | >control *a*; <*b* | 22% |
| 2 | + | + | >control; <*a*, *b* | 14% |
| 3 | 0 or − | − | <control, *a*; >*b* | 4% |

In the examples given above $A_{1-3}$ are podsolized sands of acid reaction, $A_2$ contains some ironstone. $B_1$ is a rendzina of pH 8·2, $B_2$ and $B_3$ are slightly acid red-brown loams.

3. Examples are given of the verification in the field of the results of properly conducted pot culture work. Field experience in no case disproved a definite lead given by the pot culture method, where field examination followed the exploratory test. In some cases pot culture investigation gave evidence of soil deficiency which could not be proved by field plot technique until two years later.

4. Zinc, molybdenum and potash were the most important of nine mineral elements investigated, so far as the early growth of subterranean clover was concerned.

Copper became part of the basal treatment owing to its presence in trace amounts in the distilled water employed. Despite this, however, some responses to copper were secured.

5. The regions in which field responses to zinc and molybdenum may be anticipated are indicated.

6. Response to zinc is shown to be modifiable by the conditions of both light and temperature; the effects are on the plant and not on the soil.

7. The type of response obtained was not materially affected by the size of the culture within a range of 1-5 Kg. The use of enamelled pots, which supplied zinc to the culture, or of glass jars, providing potassium or an element capable of replacing potash in a functional sense, modified the results along the lines to be expected if the element concerned were applied basally in each case.

8. Five legumes responded actively to molybdenum; barrel medic, subterranean clover and strawberry clover responded to zinc under conditions where the soil status of these two elements was low. Lucerne was the most responsive to copper of the legumes tested.

9. Superphosphate from low-grade Egyptian rock produced higher yields of subterranean clover on molybdenum deficient soil than pre-war superphosphate from higher-grade Ocean Island rock, at three levels of equivalent phosphate. This is considered to be due to molybdenum occurring as an impurity in the Egyptian rock.

10. Significant interactions between individual elements occurred in many of the tests. Potassium and molybdenum were most commonly associated in the positive interactions; manganese was more frequently concerned than any other nutrient in the negative interactions.

## Acknowledgments.

Thanks are due to Miss H. Kinnear and Mr. E. J. Leaney, who were responsible for much technical detail associated with the preparation and maintenance of the cultures.

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# Breeding Australian Barleys Resistant to Covered Smut

By

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The breeding of resistant varieties of crop plants requires a convenient and efficient method of providing a high and uniform infection in the plant population under test. Early workers with covered smut of barley found it difficult to obtain such an infection. However, in 1942 Tapke and Bever[4] devised a method of inoculation in which the seed was immersed in a suspension of spores of covered smut (*Ustilago hordei*) and then stored for 16 to 20 hours at 20° C. in a humid atmosphere. In this way they were able to secure a 40 per cent. smut infection in susceptible varieties.

In 1943 Tapke and Bever's method was found to give good results under South Australian conditions. This greatly facilitated the work already in progress which had as its objectives

(1) the determination of the relative resistance of Australian barleys to covered smut ;
(2) the identification of the races of *Ustilago hordei* in Australia ; and
(3) the incorporation of " resistant " genes in Australian varieties by the back-cross method of breeding.

The most recent report in Australia on the resistance of barley to covered smut is that of the New South Wales Department of Agriculture[1] in 1939. With the exception of Trabut, all the commercial varieties tested proved to be susceptible. Several resistant introduced varieties were being used as parents in the breeding programme of that department.

This account deals with the progress made at the Waite Institute in breeding Australian barleys resistant to covered smut.

## Methods of Testing for Resistance.

Three collections of smut were used. A collection (No. 1) from a six-rowed barley obtained from the Murray mallee in 1941 was used in the preliminary trials in 1942 and also in the varietal resistance trials of 1943 and 1944. This collection together with collection No. 2 from an unknown variety supplied by the Department of Agriculture, Western Australia, in 1943, and another (collection No. 3) from the variety Research supplied by the Victorian Department of Agriculture in 1943 were used in the physiological race determinations made in 1945.

All seed to be inoculated was first treated with a formaldehyde solution (1-320) for one hour and then washed. After drying for a few days the seed was immersed in a spore suspension (one gramme of spores per litre of water) for fifteen minutes. The seed was then dried superficially and placed in an incubator at 20° C. and high humidity for periods ranging from 9 to 18 hours. The time recommended by Tapke and Bever is 16 to 20 hours, but after 18 hours many seeds had germinated, so the length of the incubation period was reduced. After incubation the seeds were allowed to dry and then stored in envelopes until sowing. Two hull-less varieties, Nepal and Excelsior, so treated, gave a poor germination in the field which may have been due to formalin injury.

Tests conducted in 1945 indicated that no appreciable difference in infection was obtained by increasing the spore suspension to 10 grammes per litre.

In 1943 early sowing in May gave a higher percentage infection than June and August sowings, but in 1945 the time of sowing seemed to have little influence on the incidence of smutted plants.

Duplicate samples of inoculated seed were sown in the field in rows twelve feet long, with fifty grains per row.

Records of the percentage infection were based on the number of infected plants per row rather than on the number of infected heads. In moderately resistant varieties (showing about 5 per cent. infection) the results were similar whichever method of estimation was used. In susceptible varieties, a count of 40 to 50 per cent. infected heads usually corresponded with a 60 to 70 per cent. infection on a plant basis.

## Varietal Resistance.

A preliminary varietal resistance trial was carried out in 1942, the seed being inoculated with dry spores. This method of inoculation was not very effective, most varieties being free from smut while the highest infection was only 10 per cent. in the variety Cape.

Further trials in 1943 and 1944 using Tapke and Bever's method of inoculation were more satisfactory, with several varieties showing an infection of over 50 per cent. The results of these trials are set out in Table 1.

TABLE 1.

*Reactions of Barley Varieties to Collection 1 of Covered Smut* (Ustilago hordei).

| Variety. | Percentage of Smutted Plants. | | Variety. | Percentage of Smutted Plants. | |
|---|---|---|---|---|---|
| | 1943 | 1944 | | 1943 | 1944 |
| Arlington Awnless C.I. 702 | 0 | 0 | Hillsa .. C.I.1604 | 0 | 0 |
| Atlas .. .. .. | 5 | 32 | Kwan .. .. .. | 0 | 0 |
| Barbless .. C.I.5105 | 2 | 8 | Lion .. C.I. 923 | | 60 |
| Black Hull-less C.I. 666 | 14 | 60 | Lyallpur .. C.I.3403 | 0 | 0 |
| Bolivia .. C.I.1257 | 3 | 38 | Maltworthy .. .. | | 26 |
| Cape .. .. .. | 18 | 78 | Manchurian .. .. | 8 | 6 |
| Cape (Victoria) .. .. | | 56 | Marionet No. 1 .. .. | | 22 |
| Californian Feed No. 1 | | 4 | Marionet No. 2 .. .. | | 14 |
| Californian Feed No. 2 | | 2 | Nepal .. C.I. 595 | 0 | 0 |
| Chevalier .. .. .. | 21 | 20 | Nigrate .. C.I.2444 | 0 | 0 |
| Chevron .. C.I.1111 | 0 | 0 | Odessa .. C.I. 934 | | 72 |
| Coast .. .. .. | 2 | 2 | Pannier .. C.I.1330 | | 0 |
| Duckbill .. .. .. | 8 | 34 | Peatland .. C.I.5267 | 0 | 0 |
| Duplex .. C.I.2433 | 0 | 0 | Peruvian .. C.I. 935 | 0 | 0 |
| Excelsior .. C.I.1248 | | 0 | Plumage Archer .. .. | | 18 |
| Flynn .. C.I.7377 | | 50 | Prior .. .. .. | | 38 |
| Gatami .. C.I. 575 | | 0 | Research .. .. | | 14 |
| Gisborne .. .. .. | 8 | 6 | Roseworthy Oregon No. 1 | | 12 |
| Goldfoil .. C.I. 928 | 20 | 54 | Roseworthy Oregon No. 2 | | 18 |
| Goldthorpe .. .. .. | 5 | 18 | Sea of Azov .. .. | | 20 |
| Gopal .. C.I.1091 | 0 | 0 | Sulu .. C.I.1022 | | 6 |
| Hanna .. .. .. | | 60 | Trabut .. .. .. | | 24 |
| Hannchen C.I. 531 | | 0 | Trebi .. C.I. 936 | | 56 |
| Heil's Hanna No. 3 C.I. 682 | 15 | 38 | Velvon .. .. .. | | 58 |

The following varieties were free from smut in both years: Arlington Awnless, Chevron, Duplex, Gopal, Hillsa, Kwan, Lyallpur, Nepal, Nigrate, Peatland and Peruvian. In general, the commercial Australian varieties were susceptible. Californian Feed No. 1 and Californian Feed No. 2 were the most resistant of these. The resistance of Californian Feed No. 1 to a further collection of covered smut was demonstrated in the 1945 trials. Trabut, which was shown to be resistant in New South Wales, was moderately susceptible in 1944 and 1945.

## Physiological Races of *Ustilago hordei*.

In 1937 Tapke[2] was able to distinguish eight physiological races of *Ustilago hordei* using five differential barley varieties. In a more recent publication[3] he lists the reactions of an additional five races, bringing the total to 13 for the United States.

In order to determine the relationship between Australian races and those studied by Tapke in U.S.A., thirteen varieties were inoculated in 1945, with three collections of covered smut from South Australia, Western Australia and Victoria, respectively. The varieties included were: the eight varieties used by Tapke, three Australian varieties, Cape, Prior and Research, one cross-bred, Cape × Smooth Awn, and the resistant variety Kwan. The results of this trial, together with Tapke's reactions for race 5, are set out in Table II.

TABLE 2.

*Reactions of Differential Barley Varieties to Three Collections of Covered Smut in 1945. The reactions of Tapke's differentials to Race 5 are included for comparison. (See reference 3.)*

| Variety. | Percentage of Infected Plants in Duplicate Rows. | | | | | | Percentage of Smutted Heads. |
|---|---|---|---|---|---|---|---|
| | Collection 1 from S. Aust. | | Collection 2 from Victoria. | | Collection 3 from W. Aust. | | Tapke's Race 5. |
| Excelsior .. C.I.1248 | 0 | 0 | 4·5 | 0 | 0 | 0 | 0 |
| Hannchen .. C.I. 531 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lion .. .. C.I. 923 | 61·3 | 64·5 | 62·9 | 50·0 | 68·8 | 48·4 | 16 |
| Nepal .. .. C.I. 595 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pannier .. .. C.I.1330 | 9·7 | 0 | 3·8 | 8·3 | 0 | 4·2 | 0 |
| Gatami .. C.I. 575 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Odessa .. .. C.I. 934 | 90·0 | 81·5 | 88·0 | 82·1 | 76·0 | 72·7 | 38 |
| Trebi .. .. C.I. 936 | 60·7 | 46·9 | 47·1 | 37·9 | 40·0 | 42·9 | 24 |
| Cape .. .. .. .. | 74·2 | 79·4 | 34·3 | 46·9 | 30·0 | 70·0 | — |
| Cape × Smooth Awn .. .. | 14·7 | 11·1 | 3·4 | 6·5 | 29·2 | 25·9 | — |
| Kwan .. .. .. .. | 0 | 0 | 0 | 0 | 0 | 0 | — |
| Prior .. .. .. .. | 38·7 | 46·7 | 62·5 | 60·7 | 56·0 | 76·2 | — |
| Research .. .. .. | 10·3 | 29·0 | 69·2 | 37·0 | 50·0 | 80·0 | — |

On the basis of Tapke's differential reactions, the three Australian smut collections appear similar to each other, and most closely resemble race 5. The resemblance is not complete, however; Gatami, Nepal and Hannchen were quite free from smut, but the other five differentials show percentage infections higher than those listed by Tapke for race 5. Even after allowing for the different methods of assessing the percentage infection, the variety Lion seems to be more susceptible to the Australian collections than it is to race 5 of Tapke.

An examination of the reactions of the Australian varieties reveals differences between the three smut collections which are not evident when Tapke's differential varieties alone are used. The most outstanding difference is the increased susceptibility of Prior and Research to the Victorian and Western Australian collections. The duplicates agree sufficiently well to suggest that this difference is a real one. Further slight differences in the reactions of Cape and Cape × Smooth Awn are apparent.

## Inheritance of Resistance to Covered Smut (*Ustilago hordei*).

Because of its high resistance to both powdery mildew and covered smut, the variety Kwan has been selected as a parent in breeding work with these diseases.

To facilitate the breeding programme, a study was made of the inheritance of resistance in the cross Cape (susceptible) × Kwan (resistant), using the South Australian smut collection (Number 1). In 1944 the F2 families of this cross were free from smut, but the susceptible Cape parent showed only a low infection (20 per cent. smutted plants). In 1945, 147 F3 families were sown in duplicate rows, together with check rows of Cape and Kwan. Smut counts were made on a plant basis on 16 October. The figures obtained are shown in Table 3.

TABLE 3.

*The Frequency Distribution of F3 Families of the Cross Cape × Kwan with Respect to the Percentage of Covered Smut in 1945. (Collection No. 1.)*

| Classes for Smut Percentage. | 0 | 1–5 | 6–10 | 11–15 | 16–20 | 21–25 | 26–30 | 31–35 | 36–40 | 41–45 | 46–50 | 51–55 | 56–60 | 61–65 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cape .. .. .. .. | | | | | | | | 1 | 3 | 3 | 3 | 2 | — | 1 | 13 |
| Kwan .. .. .. .. | 13 | | | | | | | | | | | | | | 13 |
| Cape × Kwan F3 .. .. | 61 | 51 | 22 | 8 | 3 | 1 | 1 | | | | | | | | 147 |

The reactions of the two parental varieties were quite distinct. All the check rows of Kwan were free from smut, while Cape showed a mean infection of 46 per cent., with the standard deviation of the mean 2·4 per cent. None of the 147 F3 families was as susceptible as the parent Cape, the highest infection being 26 per cent.

The results indicate that Kwan contains more than two dominant genes for resistance to covered smut. To confirm this view further study with a larger number of individuals per family is necessary, carrying the material on to the F4 and F5 generations.

## A Breeding Programme.

There are comparatively few varieties of barley grown commercially in Australia, but those grown include satisfactory feeding and malting types. However, they have all proved susceptible to covered smut. The incorporation of " resistant " genes in these varieties would be a definite advance towards the control of this disease. This can well be achieved by the back-cross method of breeding.

As with all breeding work for disease resistance, a sound knowledge of the existing races of the pathogen and the effectiveness of the " resistant " genes available is essential. At the present time Kwan provides resistance against the Australian races so far investigated. This variety is being used as a source of " resistant " genes for transference to the varieties Prior, Research, Maltworthy and Cape. Several F5 lines of the cross (Kwan × Prior) × Prior have been obtained which are homozygous resistant to collection 1 of covered smut.

## Summary.

A number of Australian and American barley varieties have been tested for their reaction to covered smut in South Australia.

Three collections of covered smut from various parts of Australia resembled race 5 of Tapke, but differed from each other in some respects.

A back-cross breeding programme has been commenced having as its object the incorporation of covered smut resistance in Australian commercial varieties.

## Acknowledgment.

It is a pleasure to acknowledge the assistance of Mr. S. R. Hockley in this work.

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# TECHNICAL NOTES

## A SIMPLE TEST FOR THE DETECTION OF BACTERIOPHAGE ATTACKING STARTER STREPTOCOCCI.

Largely as a result of the work of Whitehead in New Zealand, it is now well established that bacteriophage contamination of bulk starter is the major cause of starter failures. Accordingly, the principal method of control is to prevent the access of phage to starter cultures, and for this purpose isolated rooms and special protective devices have been used. In spite of these precautions, and particularly in cases where it has not been possible to provide all the necessary safeguards, slowness in acid development due to phage is still occasionally experienced.

When a phage active against a particular culture has established itself in a factory, it will be found in the whey each day even though the bulk culture may be quite free. In this way a high concentration of phage is built up, so increasing the chance of infection of the bulk culture. If another starter which is not attacked by—and is thus incapable of supporting active proliferation of —this phage, is then used, the concentration in the surroundings must fall. This rather obvious fact has been made the basis of a supplementary method of starter control, namely the alternation of different starters to lessen the phage build-up against any one culture. Before changing from one starter to another, it is necessary to determine whether the phage present will attack the new culture ; hence a simple and rapid test for phage in whey is necessary.

### Sampling of Whey.

The concentration of phage in whey increases during the manufacturing process, hence samples obtained early (e.g., at cutting) may fail to contain sufficient phage. A sample of the whey draining from the curd after it is piled dry is preferred. After storage in a refrigerator overnight, a loopful is used for testing on the following day. It has been found unnecessary to filter the whey unless it is to be used for the production of plaques on agar. However, filtration through small Chamberland L.3 candles may be readily effected using the method of Asheshov.[2]

### Phage Test with Single Strain Cultures.

With single strain cultures the procedure is simple, the method of Whitehead and Cox[5] giving very clear-cut results. To 10 ml. of sterile milk add 1 ml. of sterile methylene blue solution (Wilson[6]) also two drops of starter, and a loopful of the test whey, and incubate at 30-35° C. If the culture grows normally, the blue colour will disappear in about two hours, but if lysis occurs due to phage action the blue will return to the tube ; the greater the initial phage concentration, the sooner will the blue colour reappear. If the initial phage concentration is sufficiently small, lysis may not occur before the milk has clotted, in which case a loopful of the clotted culture should be tested in the same manner on the following day.

### Phage Test with Mixed Cultures.

When mixed cultures are used the testing for phage is not so straightforward as for single strains. The methods used are based on the relative rates of acid production of control and inoculated cultures. Anderson and Meanwell[1] determined the titratable acidity after six hours at 30° C. Mattick, Nichols and Wolf[4] used a very similar method. Both procedures have several disadvantages, particularly if many cultures are to be tested. They take a comparatively long time to set up, they require a considerable amount of sterile glassware and they need considerable care in manipulation at the titration stage to avoid the spread of phage in the laboratory. Too strong an emphasis cannot be laid on the last point. In the procedure to be described, the preparation of dilutions is avoided and no titrations are necessary.

## Technique.

To each of two tubes containing 10 ml. of steamed skim milk add two drops of starter mother culture, to one add a loopful of the whey to be tested, and mix well by rotation. Incubate in a water bath at 30-35° C., and note the time of clotting. To determine when coagulation has occurred, the tubes should be tilted gently, as severe agitation at the time of clotting will result in a soft coagulum, and will render the exact time more difficult to determine. The usual practice is to examine tubes at ¼-hour intervals after 4½ hours. A difference of ¼ hour in clotting time is not significant, but differences of more than ½ hour usually indicate the presence of phage. In doubtful cases the inoculated tube may be incubated overnight and a loopful tested in a similar manner on the following day. Frequently, it is not necessary to wait for clotting, as microscopical examination of a stained smear from each tube may reveal the presence of phage. Sometimes in the inoculated tube the cocci may be seen in the act of lysis, in which case they become swollen and some will be seen to have burst. More often, the presence of phage will be disclosed in the balance of strains between the control and inoculated tubes. Whereas, for instance, the control tube may show cocci both in pairs and chains, the inoculated tube may show only chains, or perhaps one particular type of chain may be missing from the inoculated tube.

## Discussion.

Provided several active cultures differing in their phage relationships are available, application of the above test will allow starters to be rotated to avoid a heavy build-up of any one phage. The presence of phage in bulk cultures can be detected by incubating both mother and bulk cultures together and noting the difference in clotting times.

The advantage of this test is that it can be readily applied to a number of mixed cultures, and phage in the tubes can be destroyed by autoclaving without any possibility of contamination of personnel or of the laboratory. Mixed cultures are often unstable and the balance between strains is frequently changing, so that whilst on one occasion phage against one culture may not attack another, it may later be able to do so, thus necessitating frequent testing of a number of cultures. With the above method a large number of cultures may be tested quickly and without using much equipment.

The skim milk used in each pair of tubes must be from the same batch, and the same volume (usually 10 ml.) must be used in each tube. Autoclaved milk may be used for the test with single strain starters, but it is unsatisfactory where the clotting time is to be determined. Before using, the mother culture should be well mixed in the flask to avoid any unevenness in the inoculum.

Temperatures of both 30° C. and 35° C. have been used with equal success. Although it has been shown by Hunter[3] that the majority of phages proliferate more readily at 30° C. than at 37° C., the use of 35° C. may produce conditions more comparable with those obtaining in the cheese vat. Above 35° C. starter growth is seriously impaired and the clotting time is considerably extended. It should perhaps be pointed out that the clotting time of different cultures, even at 35° C., is not a measure of their activity in cheese-making. One single strain culture, which usually takes at least 6½ hours at 35° C., is much more active in the cheese vat than one mixed culture which clots in five hours. Similar discrepancies have been found between different mixed cultures, so that the test cannot be used as a substitute for either the vitality test or actual trial under manufacturing conditions.

## Summary.

1. A simple test for the presence of phage in whey, particularly when using mixed cultures, is described.

2. Advantages claimed are greater rapidity, reduction in glassware, and elimination of the possibility of phage dissemination in the laboratory.

**Acknowledgment.**

The author desires to thank the Directors of the Kraft Walker Cheese Company Proprietary Limited for permission to publish this paper.

**References.**

1. Anderson, E. B., and Meanwell, L. J. : J. Dairy Res., 13 : 58, 1942.
2. Asheshov, I. N. : J. Bact., 36 : 197, 1938.
3. Hunter, G. J. E. : J. Dairy Res., 13 : 136, 1943.
4. Mattick, A. T. R., Nichols, Agnes A., and Wolf, J. Z. : N.I.R.D. Publ. No. 794, 1944.
5. Whitehead, H. R., and Cox, G. A. : J. Dairy Res., 7 : 55, 1936.
6. Wilson, G. S. : Med. Res. Council Spec. Rep. Series No. 206, 1935.

D. I. Shew.

Kraft Walker Cheese Co. Pty. Ltd.,
Allansford, Victoria.

(Received for publication, 3rd February, 1946.)

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## WADA, A RUST-RESISTANT FLAX VARIETY.

Since the increase in importance of flax as an Australian crop during the war years, the development of a rust-resistant variety has been a major project for plant breeders in several States. The work has been actively sponsored by the Flax Production Committee, which has borne the cost of organizing annual conferences of workers associated with the project. The project has been materially aided also by the studies of Australian rust races by Drs. Waterhouse and Watson at the Sydney University.

Flax rust is a particularly important disease in Western Australia, since it readily oversummers on infected straw and is present every season, although the severity of the attack varies from year to year.[1] In severe epidemics it kills outright seedlings of varieties such as Concurrent and it also affects the yield and quality of the straw and seed. When cutworms are present in plague numbers they usually attack the straw at the site of the rust pustules.[2]

A number of linseed varieties are resistant to the known Australian rust races, and by back-crossing several institutions are endeavouring to incorporate this character in a flax variety. Direct selection from varieties has, for various reasons, received greater attention in Western Australia, and has yielded a variety which it is hoped will be available for commercial increase during 1946.

During the summer of 1942-1943 in Western Australia, unseasonal summer rains resulted in volunteer flax plants infected with rust being very abundant at planting time. Many of the crops were attacked in the seedling stage, but none as severely as a planting of Concurrent, adjacent to a retting paddock, on the property of Mr. J. Mitchell at Donnybrook. The majority of the plants were killed when they were six inches high, but a later inspection in early October revealed the presence of blue flowered plants, many of which were free of rust and much taller than the thin regrowth of Concurrent. Over four hundred rust-free plants were harvested individually, and grown as lines at the Avondale Research Station during 1944. Drought conditions prevented the development of a severe rust epidemic, but several lines segregated for resistance and flower colour. Selection between lines was also made for straw strength before the most uniform ones were bulked. The appearance, in subsequent years, of a few white flowered and rust susceptible plants in the bulked material indicates that one of the selected lines contained a plant naturally cross-pollinated with Concurrent. In tests in the flax areas of this State, and at the Sydney University with Australian collections the susceptible plants have amounted to about 0·5 per cent.

Subsequent investigation has shown that the variety Riga Crown contains about 10 per cent. of immune plants, identical morphologically with the plants in the bulked material. The Concurrent sown at Donnybrook was contaminated with Riga Crown and Liral Crown several years previous to 1943, when a variety trial was conducted.

The bulked material has been tested as the Avondale Crossbred No. 1, and will probably be released as the variety Wada. It is very similar in maturity, growth habit and appearance to Liral and Riga Crown, but it grows slightly taller. The seed yield is rather low.

In view of the place of origin of Riga Crown, it may carry the same gene or genes for resistance as D.83 and other resistant Russian varieties recently introduced. In the crosses with Concurrent referred to above the resistance appears to be inherited in a simple manner and lines have been developed which combine the resistance and early maturity of Wada with the greater straw strength and higher seed yield of the susceptible variety.

### References.

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A. J. Millington.

Department of Agriculture,
Perth, W.A.

(Received for publication, 18th February, 1946.)

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## FAILURE WITH "D.D.T." AND SUCCESS WITH "GAMMEXANE" IN THE CONTROL OF THE CULTURE MITE.

Mycologists throughout the world are plagued by mites which destroy or contaminate cultures that are left lying for any length of time. Methods of control at present in use have decided limitations. Many mycologists make use of pyridine as a fumigant but the revolting pungency of this material is almost as great a trial as the mites. In these laboratories the mite that causes damage is *Tyrophagus putrescentiæ* Schrank.* Following the demonstration that D.D.T. has no fungicidal properties (Norris, D. O., Jour. Counc. Sci. and Ind. Res., 17: 4, 289-290, Nov., 1944) it was decided to try various methods of using D.D.T. in cultures to combat the mites. The D.D.T. was used in saturated alcohol solution. In several small experiments, cultures which were already heavily infested were seeded on to slopes which had been pretreated with D.D.T. by adding the solution, draining it off into the cotton wool plug and drying for several days. Twenty-two of forty-five slopes treated in this way and all of the forty-five control slopes subsequently developed heavy mite populations.

It was thought that the failure of D.D.T. to control the mites might be due to the fungus overgrowing the D.D.T. on the agar surface sufficiently fast to prevent the mites coming in contact with it. A trial was then made starting with clean fungal cultures and treating only the cotton wool plugs after seeding by dipping them in D.D.T. solution. Two subcultures were made from each of ten newly isolated fungi from pea seed. One of each was left as control, the other was dipped and all were allowed to lie with old infested cultures. Six out of ten of the D.D.T. treated cultures and all of the controls were heavily infested after two months. The mites had penetrated unharmed a heavy barrier of D.D.T.

* Identified by Mr. H. Womersley of the South Australian Museum.

Since it was apparent that D.D.T. was not effective, attention was turned to 666 (Gammexane), which had recently attained prominence as an insecticide. The crude commercial product was used in saturated alcohol solution as for D.D.T.

Ten slopes were pretreated with D.D.T. and ten with Gammexane by the method described above. They were seeded with a newly-isolated clean culture of a green *Penicillium* sp. and were left for three months with old infested cultures. By this time, mite infestation had developed in 12/20 control tubes and 4/10 D.D.T. treated tubes, but all of the Gammexane treated tubes remained clean. In a later trial with pretreated Gammexane slopes, an infested culture of green *Penicillium* sp. was seeded to ten slopes. The cultures grew clean and remained free of mites. In both of these trials, however, it was noted that the fungus would not grow at all on the Gammexane treated surface, and grew very slowly and atypically only after the surface was broken to expose fresh agar. Subsequent subculture to untreated slopes gave normal colonies.

During the time that the preceding experiments were being done, trouble was being experienced in other work from a species of *Acrostalagmus*. This fungus appears to be ideally adapted for transmission by such carriers as mites. It forms countless minute conidia in slimy heads. These conidia adhere to the mites and are transferred from tube to tube as the mites wander. In many cases, the track of a mite walking across the agar could be clearly seen by the subsequent development of a trail of colonies of *Acrostalagmus*. It was resolved to make use of this association of mite and fungus for a further comparison of D.D.T. and Gammexane.

A number of cultures of *Acrostalagmus* were obtained as sources of contamination and a number of old infested cultures as sources of mites. Fresh sterile agar slopes were used. The plugs of five were dipped in D.D.T. solution, and the plugs of ten in Gammexane solution. Fifteen slopes were left untreated as controls. All were allowed to lie in a heap with the *Acrostalagmus* and mite-infested cultures. After two months 13/15 of the control slopes were infested with mites and heavily contaminated with *Acrostalagmus*. 3/5 of the D.D.T. slopes were similarly contaminated but the Gammexane slopes remained sterile. All contaminated tubes were then heaped on the Gammexane tubes and left for another month. The Gammexane slopes remained sterile.

In addition to these experiments the method of dipping plugs in Gammexane solution has been adopted as standard practice for some time. Large numbers of subcultures of fungi and *Rhizobium* spp. have been made in this time but no trace of mite invasion or of mite-borne contamination has developed, despite the fact that old infested cultures have been kept adjacent.

The use of Gammexane solves the problem of keeping new cultures clean in a simple and satisfactory manner. It has been customary in the experiments described here to dip the cotton wool plugs after seeding the cultures. Unless the dipping is done very quickly the plugs absorb so much alcohol that growth of the organism is interfered with by alcohol vapour. It would therefore be preferable to dip all plugs as soon as the medium is prepared so that they have dried before the slopes are used. It is also quite possible that a dust containing a percentage of Gammexane would be equally satisfactory, although this would tend to contaminate plugs instead of sterilizing them as does the alcohol solution.

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(Received for publication, 5th April, 1946.)

## A SIMPLE HAND DUSTER FOR THE APPLICATION OF ABRASIVES AND INSECTICIDAL DUSTS IN PLANT VIRUS TRANSMISSION STUDIES.

The application of carborundum to the leaves of test plants by means of a salt shaker to facilitate the mechanical transfer of certain plant viruses has been recommended by Rawlins and Tompkins.[1]

The author found this method of application unnecessarily tedious and time-consuming when inoculating large numbers of plants.

During the past three years very consistent results have been obtained in the mechanical transfer of a number of plant viruses (tomato spotted wilt, cauliflower mosaic, legume mosaics, etc.), when the abrasive (600 mesh aloxite or carborundum) has been applied prior to inoculation by means of a hand duster of very simple design.

As illustrated in Fig. 1, the duster is constructed mainly from an erlenmeyer flask of 250 ml. capacity, and a De Vilbiss atomizer bulb.

*Figure* 1.

Hand duster showing, on left, details of construction and, on right, its use in applying carborundum dust.

The duster has also been used very successfully in connexion with aphid transmission experiments with a virus disease of carrots.[2] In the earlier experiments with this virus difficulty was experienced in standardizing the conditions of nicotine vapour fumigation necessary to kill the insects used and injury to test plants often occurred.

By means of the duster, a commercial 3 per cent. nicotine dust is applied through the muslin tops of cylindrical celluloid cages used for covering test plants following aphid transfers (Fig. 2). The presence of the cage concentrates the dust on all parts of the plant and in addition increases the efficiency of the fumigatory action of the nicotine.

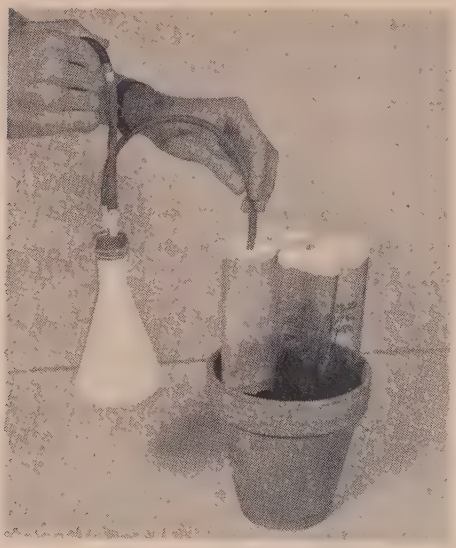

*Figure* 2.

Illustrating use of hand duster for fumigation purposes.

In a large number of transmission experiments conducted with the aphids *Cavariella ægopodii* Scop., *Anuraphis tulipæ* Boyer and *Hydaphis sii* Koch, this method has been completely successful in killing the aphids without injuring the test plants. *Anuraphis tulipæ* sometimes survived fumigation with nicotine vapour, but always succumbed to the nicotine dusting process. The majority of plants subjected to this treatment have been members of the *Umbelliferæ* and some of the native species used in transmission tests were very susceptible to injury when the nicotine sulphate volatilization process of fumigation was used.

Cages have been left in place for as long as 24 hours following dusting, but they can usually be removed with safety after one or two hours.

## References.

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2. Stubbs, L. L., and Grieve, B. J.: J. Dep. Agr. Vict., 42: 411-412, 1944.

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(Received for publication, 3rd April, 1946.)

# The Australian Institute of Agricultural Science

## SPECIAL GENERAL MEETING.

A special general meeting of the Institute, to be held in conjunction with the Adelaide meeting of the A.N.Z.A.A.S., has been fixed for Monday, 19th August, commencing at 2 p.m., and continuing on the 20th. This meeting will concern itself with general Institute business. It is expected that research papers will be submitted to Section K of the A.N.Z.A.A.S. meeting, which is referred to more fully under Current Notes and News.

## EIGHTH GENERAL MEETING.

This meeting, held in Sydney on 8th March, 1946, unfortunately could not have the widely representative character of the seventh general meeting, and discussion on policy matters was precluded. The retiring President (Dr. B. T. Dickson), recently unanimously re-elected for a further term, delivered a presidential address, which is published on page 1 of this issue.

Reports of the Council, the Editor and Business Manager of the Journal and a statement of accounts and the balance sheet from the auditors were received. The financial statement appears on p. 57. The report of Council was as follows :

*Membership.*—The following table shows the corporate membership position as at 31st December, 1944 (auditor's statement) and changes which have occurred during the year 1945 :

| Branch. | Membership at 31/12/44. | Gains by Admissions and Transfers during 1945. | Losses by Death, Resignations, Cancellations and Transfers during 1945. | Membership at 31/12/45. | Student Membership at 31/12/45. |
|---|---|---|---|---|---|
| N.S.W. .. | 148 | 25 | 5 | 168 | 33 |
| Vic. .. | 149 | 9 | 8 | 150 | 4 |
| W.A. .. | 67 | 4 | 1 | 70 | 16 |
| S.A. .. | 58 | 9 | 4 | 63 | 10 |
| Qld. .. | 55 | 5 | — | 60 | — |
| A.C.T. .. | 33 | 4 | 3 | 34 | — |
| Tas. .. | 18 | 1 | — | 19 | — |
| Total .. | 528 | 57 | 21 | 564 | 63 |

The number of corporate members admitted during 1945 was 43 and student members 32, and total corporate membership has now risen to 564.

Your Council records with deep regret the death since last general meeting of the following member of the Institute : Dr. J. Davidson, Professor of Entomology, Waite Research Institute, and the following Service casualties : F./Sgt. P. W. B. Gurdon, R.A.A.F., killed in air operations overseas ; Sgt. G. H. Clarke, died as a prisoner of war in Burma ; Sgt. S. M. Close, reported missing, believed killed in air operations overseas ; Capt. A. H. Bishop, prisoner of war in Java, released 1945.

With the cessation of hostilities, we are happy to report that most of our members who were in the services have now returned to Australia, and many other members who were engaged on war-time work have resumed their peace-time occupations.

*Branch Activities.*—A feature of the year's activities has been a number of well attended meetings conducted by various Branches for discussion of public questions of current interest and importance. During the year Branches have given further consideration to the resolutions passed at the seventh general meeting and advised Council of Branch opinion on them. A notable event was the creation of the Murrumbidgee sub-branch of the N.S.W. Branch—the first sub-branch to be formed.

*Transfer of Office of Management to N.S.W.*—The Office of Management of the Institute was officially transferred to Sydney on the 26th February, 1945, and Council meetings have been held at two-monthly intervals, beginning in April. Whilst the registered office of the Institute remains in Melbourne, Sydney firms of auditors and solicitors for the Institute have been appointed.

*Institute Journal.*—During the year the transfer of the office of publication of the Journal to Adelaide was effected. Volume 11, Nos. 1 and 2 were produced before this transfer was effected, by a Publications Committee of N.S.W. members, which consisted of Dr. H. J. Hynes (chairman), Dr. Lilian Fraser (Editor), Mr. N. C. Lloyd (Business Manager), Dr. E. T. Edwards, Mr. W. Poggendorff and Dr. I. A. Watson.

Subsequent issues of the Journal were assigned to the charge of a Publications Committee of South Australian members comprised of Mr. D. B. Adam (Editor), Dr. C. S. Piper (Business Manager), Dr. T. J. Marshall and Messrs. H. G. Andrewartha and K. Woodroffe. Unfortunately industrial disputes in N.S.W. have prevented the issue of Nos. 3 and 4 up to the end of the period of this report.

*Qualifications Committee.*—The retiring members of the Qualifications Committee, Professor J. A. Prescott, Dr. A. R. Callaghan and Mr. Rowland Hill, were asked to continue in office in the early part of 1945, but as a consequence of the decision that Institute committees rotate among Branches, a Qualifications Committee of Victorian members, namely Messrs. A. J. Vasey (convener), J. A. Aird and G. W. Leeper, was appointed in June, 1945. This committee has dealt with 67 applications for corporate and student membership.

*Manpower Arrangements.*—Manpower Advisory Sub-committees continued to operate during the early part of the year while manpower controls remained in operation.

At a meeting of representatives of professional manpower advisory committees in Sydney, at which the Institute was represented, the Controller of Scientific Manpower expressed appreciation of the services performed by the professional advisory committees and opened preliminary discussions on the desirability of a Higher Appointments Office in the Commonwealth Employment Service.

*Seventh General Meeting.*—After a lapse of six years, embracing the war period, the Institute held a fully representative general meeting on 13th-15th February, 1945, at the School of Agriculture, Melbourne University, the proceedings of which are contained in a *verbatim* report. Subsequent action by Council on resolutions passed at this meeting is as follows :

*Sponsoring of Conferences.* Following discussions at which the attitude of the Institute towards the sponsoring of conferences was more clearly defined, it was decided to sponsor a conference of cereal plant breeders and geneticists. Representations have been made to the Australian Agricultural Council, requesting its support for such a conference.

*Policy of Publicity.* A sub-committee of Council considered the question of Institute publicity, and its recommendations were adopted in regard to the setting up of a Publicity Committee of Council and Branch publicity officers.

*Functioning of Proxy Council.* The procedure recommended in the relevant resolution has been adopted and has been working smoothly. Proxy Councillors have received the approval of their principals in regard to power of compromise, and this has facilitated Council deliberations on several occasions.

*Method of Election of President.* A sub-committee of Council reported on the method of election of President, and as a result By-law 1, clauses 1 to 6, was adopted as the procedure to be followed in filling this office.

*Returned Soldier Preference.* The resolution of the seventh general meeting was conveyed to the Minister for Post-War Reconstruction and members on active service were advised of the text of the resolution.

*Salaries and Status.* The Institute report on salaries of the 19th February has been brought to the notice of the Rural Reconstruction Commission and appropriate Commonwealth authorities. Branches have submitted the schedule to the notice of State employing authorities and it is understood to be a basic consideration in negotiations at present being carried out by more than one Branch.

*"Australian Journal of Agricultural Science."* A sub-committee of Council has conducted enquiries as to the attitude of agricultural institutions towards the proposal to publish an *Australian Journal of Agricultural Science.* These enquiries, coupled with those on an abstracting service, as yet are not quite complete. Other enquiries have indicated that financial support for the proposed journal would be forthcoming from an outside source.

*Need for All-Australian Agricultural Policy.* The implementation of the resolutions arising from the session on "The Post-War Structure of Australian Agriculture" of the seventh general meeting occasioned protracted discussions at Council meetings and diversity of opinion among Branches. Following the establishment of the validity of the most contentious resolution, a covering statement was prepared which is to be forwarded to Commonwealth authorities by the President. This statement covered the resolutions on the coordination of Australan agricultural policies, the need for an All-Australian agricultural policy, staffs for Commonwealth service, conditions of employment in Commonwealth service and the coordination of agricultural research. Consideration is still being given by Branches and Council to a number of different aspects embraced in the resolution on agricultural education.

*Payment of Rebates.*—The practice established in 1944 of paying rebates to Branches in respect of members on war service was continued. During the year Council approved of a rebate to Branches in respect of student members, at the rate of 2*s.* 6*d.* each per annum.

## THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE.

### Income and Expenditure Account for the Year Ended 31st December, 1945.

#### EXPENDITURE.

| 1944. £ s. d. | | 1945 £ s. d. |
|---|---|---|
| 183 16 11 | To Cost of Journal | 90 6 6 |
| | „ Annual Meeting Expenses | 232 2 10 |
| 44 18 6 | „ Printing and Stationery | 15 19 3 |
| 8 8 0 | „ Audit Fees | 8 8 0 |
| 14 15 8 | „ Petty Cash and Incidentals | 54 10 2 |
| | „ Grants to Branches— | |
| 42 1 6 | Victoria | 36 11 6 |
| 26 13 6 | New South Wales | 53 13 0 |
| 18 3 0 | South Australia | 18 18 6 |
| 14 6 0 | Queensland | 11 16 6 |
| 19 5 0 | Western Australia | 12 12 6 |
| 12 7 6 | Australian Capital Territory | 9 12 6 |
| 4 2 6 | Tasmania | 6 17 6 |
| 388 18 1 | „ Total Expenses for the Year | 551 8 9 |
| 71 6 11 | „ Surplus for Year | — |
| £460 5 0 | | £551 8 9 |

#### INCOME.

| 1944 £ s. d. | | 1945 £ s. d. |
|---|---|---|
| | By Subscriptions Received— | |
| 129 3 0 | Victorian Branch | 121 18 9 |
| 107 7 0 | New South Wales Branch | 168 8 0 |
| 45 2 0 | South Australian Branch | 64 0 0 |
| 39 18 0 | Queensland Branch | 40 19 0 |
| 71 10 0 | Western Australian Branch | 65 4 0 |
| 36 15 0 | Australian Capital Territory Branch | 31 10 0 |
| 15 15 0 | Tasmanian Branch | 25 4 0 |
| 14 15 0 | „ Interest Received | 9 7 6 |
| 460 5 0 | | 526 11 3 |
| | „ Deficit for the Year | 24 17 6 |
| £460 5 0 | | £551 8 9 |

### Balance Sheet as at 31st December, 1945.

#### LIABILITIES.

| 1944 £ s. d. | | 1945 £ s. d. | £ s. d. |
|---|---|---|---|
| | Sundry Creditors— | | |
| | Branch Grants | 154 10 0 | |
| 166 0 9 | General | 8 8 0 | |
| | | | 162 18 0 |
| 4 4 0 | Subscriptions Paid in Advance | | 6 6 0 |
| | Accumulated Fund— | | |
| | Balance at 31/12/1944 | 814 0 4 | |
| 814 0 4 | *Less* Deficit for year ended 31/12/1945 | 24 17 6 | |
| | | | 789 2 10 |
| £984 5 1 | | | £958 6 10 |

#### ASSETS.

| 1944 £ s. d. | | 1945 £ s. d. | £ s. d. |
|---|---|---|---|
| | Cash at Bank— | | |
| | Sydney | 494 12 2 | |
| | Adelaide | 50 0 9 | |
| | | | 544 12 11 |
| 407 4 8 | | | |
| 100 0 0 | Fixed Deposit | | 100 0 0 |
| 100 0 0 | Commonwealth Government Bonds 3¼%, due 15/8/1956 | | 100 0 0 |
| 100 0 0 | Commonwealth Government Bonds 3¼%, due 15/11/1958 | | 100 0 0 |
| 200 0 0 | Commonwealth Government Bonds 3¼%, due 15/9/1959 | | 200 0 0 |
| 4 5 0 | Interest Accrued | | — |
| 60 7 0 | Subscriptions Outstanding (since collected) | | — |
| 9 5 0 | Office Furniture | | 9 5 0 |
| 3 3 5 | Petty Cash on Hand | | 4 8 11 |
| £984 5 1 | | | £958 6 10 |

The above Balance Sheet has been prepared from the books of account, accounts and vouchers of The Australian Institute of Agricultural Science and is a correct statement of the position of the Institute's affairs on the 31st December, 1945, as disclosed thereby.

Prudential Building,
39 Martin Place,
Sydney.

4th March, 1946.

HORLEY & HORLEY,
Chartered Accountants (Aust.).

*Admissions to Membership.*—As the result of representations to principal delegates on a means of expediting admission to membership, it was generally agreed that proxy Council should be empowered to admit applicants for membership in regard to whom favourable reports from the Branch submitting the application, and the Qualifications Committee, had been received. In regard to applicants, reports on whom were not entirely favourable, a summary of qualifications will be circulated to delegates as in the past.

For and on behalf of the Council,

(Signed) B. T. Dickson,
President.

## MEETINGS OF COUNCIL.

A Council meeting was held at Science House, Sydney, on Tuesday, 4th December, 1945.

*Present.*—The President, Dr. B. T. Dickson (in the chair), E. T. Edwards (N.S.W.), N. S. Noble (Qld.), J. R. A. McMillan (A.C.T.), R. D. Croll (Vic.), R. H. Anderson (Tas.), H. J. Hynes (S.A.), G. de V. Davis (W.A.), the Hon. Gen. Treasurer, F. C. McCleery, and the Hon. Gen. Secretary, F. T. Bowman.

The resignation of Mr. Croll as from 5th December, 1945, and the appointment of Mr. H. J. Geddes in his stead, were announced. The President, expressing regret at the loss of Mr. Croll from Council deliberations, congratulated him on the promotion which necessitated his removal to Victoria.

Congratulations of the meeting were extended to Mr. J. G. Crawford, member of the Commonwealth Delegation to the meeting of the United Nations' Food and Agriculture Organization, Quebec City, Canada.

The Hon. Gen. Secretary reported having extended best wishes to the M.I.A. Sub-branch of the Institute on the occasion of its inaugural meeting.

*Australian Agricultural Policy.*—A full discussion of Branch views revealed a majority desiring that the resolutions of the general meeting should go forward, and a majority desiring a new covering statement. Finally it was resolved :

> That in reference to the expression of Branch opinion on the question of the proposed statement for attachment to the resolutions on an All-Australian Agricultural Policy and taking note of the fact that Branches in favour of attaching a covering statement had a voting strength of 397 as compared with a voting strength of 113 from Branches opposed to such action, *resolved* that Dr. MacMillan, Mr. Croll and Mr. Davis (convener) be directed to draw up a statement, as far as possible reconciling the opinions expressed by Branches with the original Council statement and to circulate such new statement amongst members of Proxy Council for approval ; and, further, that upon such approval being obtained, the said new statement, together with the said resolutions, shall be forthwith forwarded to the competent Commonwealth Authorities.

This statement and the resolutions to which it refers appears among the Current News and Notes on p. 64.

It was decided that the Institute should hold a meeting immediately prior to the A.N.Z.A.A.S. meeting in August, and that this should be regarded as a special general meeting. This meeting is referred to elsewhere.

*Membership.*—The following applicants were admitted to membership :—to Corporate membership : H. N. England (N.S.W.), R. H. Kuchel, G. A. Stewart, R. Brewer (S.A.), F. R. Drake (Vic.), R. H. Morris (W.A.). To Student membership : D. E. Shaw, J. Redrup (N.S.W.) ; J. S. Russell (S.A.) ; J. P. Fallon, J. K. Powrie (W.A.) ; A. Shavitsky, J. H. Wilson (Vic.). The following inter-Branch transfers were noted : W. M. Willoughby (A.C.T. to N.S.W.), G. P. Phillips (N.S.W. to A.C.T.). The following resignations were noted with regret : F. Wilson (A.C.T.), A. T. Jefferis (S.A.).

*Re-Election of Members.*—Following discussion, the procedure to be adopted in re-election to membership was decided as follows :

1. The Branch Secretary submitting a former member for re-election should state :
   (*a*) The reason for termination of previous membership, i.e., resignation, termination by Council, etc.
   (*b*) Whether arrears of subscriptions required under Article 21 had been paid.
2. The Branch Secretary should forward to the Qualifications Committee the above details, together with any other particulars of the case on which the Committee may judge of the applicant's qualifications (including present employment) for readmission.
3. Council will consider re-election on receipt of the recommendation of the Qualifications Committee.

A Council meeting was held at Science House, Sydney, on Tuesday, 12th February, 1946.

*Present.*—E. T. Edwards (in chair), N. S. Noble (Qld.), J. R. A. McMillan (A.C.T.), H. J. Geddes (Vic.), R. H. Anderson (Tas.), G. de V. Davis (W.A.), the Hon. Gen. Treasurer, F. C. McCleery, the Hon. Gen. Secretary, F. T. Bowman. Mr. K. O. Campbell was present by invitation to represent N.S.W. Branch.

Apologies for absence were received from Drs. B. T. Dickson and H. J. Hynes.

Congratulations of the meeting were extended to Dr. Underwood on his appointment as Professor of Agriculture in the University of W.A.

*Election of President.*—The Hon. Gen. Secretary reported that the single nomination of Dr. B. T. Dickson had been received and the Chairman formally declared him elected President of the Institute for 1946.

Other business discussed at the meeting is covered by the report of Council to the eighth general meeting, which appears on p. 55.

*Membership.*—On the recommendation of the N.S.W. Branch it was decided to terminate, on account of non-payment of dues, the membership of Messrs. G. M. Donald and A. C. T. Kellick.

The resignation of Mr. A. H. E. McDonald of the N.S.W. Branch was accepted with regret.

The following transfers were noted: C. G. Greenham (N.S.W. to A.C.T.), R. H. Hayman and Miss Joan Demaine (Vic. to N.S.W.), R. D. Croll (N.S.W. to Vic.), R. A. Sherwin (Tas. to N.S.W.).

## MEETINGS OF BRANCHES.

### Australian Capital Territory Branch.

A meeting of the Branch was held on 13th February, when Mr. H. Smith addressed members on the "Rubber Institute of Malaya".

The eleventh annual meeting was held on 27th March, and owing to the unexpected absence of the President, Dr. C. Barnard, was confined to the formal business of electing office-bearers for 1946. The following were elected: President and Delegate, Mr. C. M. Donald; Hon. Secretary-Treasurer, Mr. G. A. McIntyre; Hon. Sub-Editor of Journal, Mr. G. A. H. Helson; Committee, Dr. C. Barnard, Mr. T. G. Campbell; Hon. Auditors, Messrs. E. M. Hutton, D. O. Norris.

### New South Wales Branch.

A meeting of the N.S.W. Branch of the Institute was held on 15th February. The following were elected office-bearers of the Branch for 1946: President, Dr. C. J. Magee; Vice-President, Mr. H. Parry Brown; Hon. Secretary, Dr. I. A. Watson; Hon. Treasurer, Mr. R. H. Arnot; Committee, Dr. E. T. Edwards, Mr. J. M. Vincent, Mr. K. O. Campbell; Hon. Sub-Editor of Journal, Dr. Lilian Fraser; Public Relations Officer, Mr. H. Parry Brown.

The retiring President, Mr. H. Parry Brown, delivered the Presidential Address, entitled "Rural Adult Education".

### Queensland Branch.

Mr. P. J. Skerman, who recently came back to Queensland after a period as a lecturer at Hawkesbury Agricultural College, gave an address on "Agricultural Extension Work in New South Wales" to the Queensland Branch at its meeting on 28th November, 1945. The speaker remarked that this type of work is much more advanced in the neighbouring State than in Queensland.

The Branch Committee elected at the eleventh annual general meeting of the Queensland Branch, held in March, comprised: President, O. St. J. Kent; Vice-Presidents, C. J. McKeon and D. O. Atherton; Hon. Editor, C. G. Hughes; Hon. Secretary-Treasurer, C. W. Winders; Committee Members, Messrs. A. R. Brimblecombe, W. J. S. Sloan and C. R. von Stieglitz. Four members of the Branch remained in the services at 31st December, 1945. The financial statement presented to the meeting showed an excess of assets (including war savings certificates valued at £41 12*s.* 6*d.*) over liabilities of £82 6*s.* 4*d.*

### Victorian Branch.

Members attended a meeting of the Melbourne University Agricultural Society on 30th November, when one of their number, the newly appointed Superintendent of Agricultural Education in Victoria, Mr. G. B. Woodgate, spoke on "Vocational Education in Agriculture". Mr. Woodgate traced the history of agricultural education in this State, pointing out that it was just 60 years from the time the need for this type of education was first recognized here until the Council of Agricultural Education had been abolished last year and control transferred to the Minister for Agriculture, assisted by an advisory committee. He forecast a change in the method of training agriculturists if the needs of the community were to be adequately catered for. This included curtailment of much of the monotony associated with practical work at the agricultural colleges, a corresponding increase in work of a demonstrational nature, shorter college courses and a trend towards specialization. Care would be needed, he said, in gathering a staff together, not to become divorced from the practical. On the other hand, a blind worship of the practical would be equally foolish. The new division hoped eventually to set up an effective scheme of correspondence courses (a satisfactory substitute, when other forms of training were not available), sponsor senior young farmers' clubs and cater also for adult education in agriculture by periodic refresher courses.

Members again attended a meeting of the M.U.A.S. on 22nd March, when Dr. M. E. Winfield, Research Officer, Division of Industrial Chemistry, C.S.I.R., spoke on " The Importance of Boron in Plant Growth ".

Boron had been shown necessary for the growth of a great many crop plants, said Dr. Winfield. Monocotyledons required only about one-tenth as much boron as dicotyledons, while animals, fungi, and most, but not all, bacteria and algæ appeared not to need it. Throughout the world a considerable number of soils had been found deficient in boron. Few such areas had been discovered in Australia, but this did not mean that we could anticipate little trouble with boron deficiency. The likelihood of the trouble developing increased with time—working of the soil for long periods, leaching, over-liming and the use of certain synthetic fertilizers all contributed to bring about the deficiency. Moreover, the disease in its incipient form was often difficult to detect. The only effect apparent might be a sub-optimum yield, particularly when the plants were receiving a great deal of sunshine.

Mild boron deficiency in certain crops was found to result in appreciable lowering of the content of vitamin A and chlorophyll. Furthermore, boron exerted considerable influence on the absorption of other ions, and therefore on the mineral content of the crop, so that its nutritive value was to some extent dependent upon the boron content. Sub-optimum boron nutrition lessened drought resistance, detracted from the keeping qualities of fruit, and interfered with nodule formation of leguminous roots.

Certain areas, far from having too little boron, had too much, generally as the result of irrigation. A moderate excess of boron resulted in scorching of the older leaves without influencing greatly the yield of fruit, while a larger excess might result in serious crop losses. Boron excess could be overcome in some cases by judicious application of calcium carbonate to the soil: but there was danger in such procedure that other necessary elements might be rendered unavailable.

Following a theoretical treatment of the chemistry of boron in the soil and in the tissue, it was assumed that boron entered the plant as boric acid or borate. After entering the cell it existed as a complex with one or more of the many cell constituents which were capable of complex formation with boric acid. Which particular constituents were actually involved was still not known. Nevertheless it was possible to give illustrations of the types of chemical change to which boron might owe its function in the plant. These included the reversible reduction of the borate complex of vitamin $B_6$; the synthesis of vitamin $B_2$ by condensation of alloxan with dimethyl-amino-ribamine in the presence of boric acid; and the polycondensation of 2, 3-butanediol in the presence of boric acid.

*In vitro*, borate influenced the rate of degradation of starch to glucose-1-phosphate and the reverse process of starch synthesis, but the effect was probably too small to be of significance in the normal plant. Roots were remarkably insensitive to concentrations of boron which were customarily regarded as toxic. The respiration of boron-deficient tomato roots was not stimulated in twenty-three hours by the addition of small amounts of boric acid to the substrate, nor was it markedly inhibited by high concentrations. Normal barley roots were more sensitive to an excess of boron, 750 p.p.m., inducing 60 per cent. inhibition after four hours, concluded Dr. Winfield.

## Tasmanian Branch.

The following officers were elected to the Committee at the eleventh annual general meeting: President, Mr. F. E. Ward; Vice-Presidents, Mr. F. W. Hicks and Mr. F. H. Johnstone; Secretary, Mr. W. F. Walker; Treasurer, Mr. L. Millar; Sub-Editor and Publicity Officer, Mr. T. D. Raphael; Auditor, Mr. J. Gemmell.

Mr. F. W. Hicks, the retiring President, gave an address on " The Trend of Post-War Agricultural Activities ". Some points from his talk are given under " Current Notes and News " on p. 65.

## South Australian Branch.

The eleventh annual meeting of the Branch was held on 26th March. Mr. L. V. Toyne, Vice-Consul to the American Consulate-General in Sydney, addressed the meeting on " The Land Grant College System in the United States ". He outlined the development of the system since its foundation in 1862, when the Federal Government made a grant of land to each State to be used for an agricultural college. Further Federal help came with the establishment of the experimental stations in 1887 and a Federal extension service in 1915, cooperating with the State services. At the present time there are forty-nine of these colleges in the United States. Mr. Toyne discussed further the Agricultural Adjustment and Administration Act and the legislation concerning the Soil Conservation Service in 1935. He outlined the relation between research and extension and spoke of the importance attached to conservation of soil, water and human resources.

The following Committee was appointed for 1946: President, Mr. H. G. Andrewartha; Vice-President, Mr. A. G. Strickland; Hon. Sub-Editor of Journal, Dr. T. J. Marshall; Hon. Secretary, Mr. N. T. Flentje; Hon. Treasurer, Mr. K. Woodroffe; Committee Members, Miss N. T. Burbidge, Mr. E. J. Breakwell, Mr. L. J. Cook; Member *ex officio* (immediate past President), Mr. J. K. Taylor.

### Western Australian Branch.

At a general meeting on the 12th October, Dr. E. J. Underwood addressed members and visitors on " Some Fertility Problems in Animals ". Following a review of the history of the physiology of reproduction, Dr. Underwood traced the work that led to the recognition and isolation of the sex hormones and the production of the synthetic hormone diethyl stilbœstrol.

For some time it had been recognized that the anterior pituitary had some governing function in sex, and subsequently three protein-like gonadotrophins were isolated.

Fertility could be defined as the ability of an animal to produce live young. Many primitive animals have only one breeding season each year, but most modern domesticated animals have œstrus cycles continuing throughout the year except when interrupted by pregnancy. Sheep have usually definite breeding and non-breeding seasons. The breeding season varied with breed and to some extent locality, starting slightly earlier in W.A. than in the eastern States. During these cycles œstrus and ovulation occur, and if fertilization takes place pregnancy follows. The number of young depends in the first instance on the number of ova shed. This is controlled by the anterior pituitary's gonadotrophins, and several investigators have claimed to have increased the number of twins to 50 per cent. by injections of these hormones. Correct dosage is difficult, as over-dosage gives multiple births with lowered viability. Nutrition also plays some part as shown by the recognized value of flushing in raising the percentage of twins.

The number of ova fertilized depends on the sperm condition of the male, the time relation between mating and ovulation, and the condition of the genital tract of the female.

High sperm numbers are necessary to give sufficient hyaluronidase to enable penetration of the ovum by the sperms. Dr. Gunn had shown that vitamin A, high temperature fevers, fly strike and other factors all affected sperm production.

The ovum only survives two to three hours, and most female animals will only take the male during œstrus. The time of mating is important, as it takes up to 24 hours for the sperms to get to the ovary. Ovulation usually occurs after œstrus, so that in long œstrus periods, as in the mare, fertilization might not take place. The condition of the female tract is important, as any inflammatory condition is inimicable to sperms. This is of great importance in dairy cows. Nutritional factors such as mineral or protein deficiencies also are important. There is also a hormonal control, imbalance causing a cystic condition of the endometrium.

Other points from Dr. Underwood's talk are given under " Current Notes and News " on p. 65.

At a meeting on 7th December, Professor Currie addressed members on " A Scheme for the Rural Training of Returned Service Personnel ". This scheme is the subject of an article on p. 5 of this issue.

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# Current Notes and News

### Australian and New Zealand Association for the Advancement of Science.

The twenty-fifth meeting of the Australian and New Zealand Association for the Advancement of Science will be held in Adelaide from Wednesday, 21st, to Wednesday, 28th August, 1946. The President-Elect is Dr. P. Marshall of Wellington, New Zealand.

*Section K, Agriculture and Forestry*, will meet under the presidency of Mr. C. J. Rodger. The joint secretaries for the Section are Mr. K. Woodroffe, c.o. Waite Agricultural Research Institute, and Mr. J. Thomas, Woods and Forests Department, Adelaide.

The tentative programme for Section K includes sessions on the following subjects :

1. Presidential Address : The Place of Softwoods in Australian Forestry.
2. Soil and Forests : Soil surveys in relation to afforestation ; soil fertility problems associated with afforestation.
3. Current Problems in Land-use.
   (*a*) Agricultural areas ; development of a permanent agriculture.
   (*b*) Development of poor soils in areas of high rainfall.
4. Climatology in Relation to Agriculture and Forestry. (Joint session with Section P, Geography.)
5. Soil Microorganisms in Relation to Soil Fertility and Plant Disease. (Joint session with Section M, Botany.)

It is hoped to provide also for the reading of a limited number of papers on subjects not related to the above. Sectional excursions to Mt. Crawford Forest, Roseworthy College, and the Waite Institute are planned.

The committee of Section K will be glad to receive for consideration offers of papers. Persons interested in agriculture and forestry who expect to be able to attend the meeting are requested to forward their names to one of the joint secretaries.

Further general information and tentative programmes covering all sections will be obtainable shortly from the local secretary for the meeting, Dr. R. S. Burdon, c.o. the University, Adelaide. All enquiries for accommodation should be addressed to the Director, Government Tourist Bureau, Adelaide, and not to the local secretary.

## Hackett Professor of Agriculture.

The Hackett Chair of Agriculture, recently vacated by Professor G. A. Currie on his appointment as permanent Vice-Chancellor of the University of Western Australia, is now occupied by Dr. E. J. Underwood, formerly Animal Nutrition Officer in the W.A. Department of Agriculture. This is the first occasion on which a graduate of the University of W.A. has been appointed to a chair within the University.

The Chair of Agriculture in the University of W.A. came into being when the University was founded in 1911 and is wholly maintained by a bequest by the late Sir John Winthrop Hackett, the University's first Chancellor and its greatest benefactor. This professorship carries with it the position of Director of the University Institute of Agriculture, a research institute founded during the tenure of the Chair of Agriculture by Dr. J. E. Nichols.

Professor Underwood.

Professor Underwood was born in London in 1905 and came to Western Australia in 1913. He entered the University from the Perth Modern School in 1924, at the same time gaining a cadetship in the W.A. Department of Agriculture. He was awarded the Norman Albert Prize for Agriculture and the Amy Saw Scholarship, and graduated B.Sc.Agric. in 1927. In 1928 he obtained first-class honours in agriculture and with a Hackett Research Studentship proceeded to Cambridge for post-graduate study and research on pastures and animal nutrition. He was granted the degree of Ph.D. in 1931. After five years' research work on animal problems in the W.A. Department of Agriculture, he was awarded a Commonwealth Fund Service Fellowship. He spent two years in research and study at the University of Wisconsin and in travel throughout the United States of America and Canada. A further three months were spent travelling in Great Britain and South Africa. In 1939 he resumed his work in the W.A. Department of Agriculture.

Professor Underwood's research activities have been maintained on an unusually wide front. His pasture investigations have dealt with the botanical and chemical composition of Western Australian and English pastures and the influence of fertilizer treatments on yield and composition. On the animal disease side, his work with J. F. Filmer on "Denmark wasting" disease of cattle and sheep led to the discovery of cobalt as a new "trace" element in ruminant nutrition. In addition he has contributed to the knowledge of supplementary feeding by working on toxic paralysis of sheep in the W.A. wheat belt.

Still proceeding is the investigation into the new major sheep problem in the "clover belt" of Western Australia. Infertility, dystocia and prolapse of ewes are involved. Work in animal husbandry has been concerned mainly with the factors governing the numbers, size, growth rate and carcase quality of "export" lambs. In nutrition and biochemistry he has studied the metabolism and distribution of "trace" elements; aspects of vitamin A and carotene in sheep nutrition; the phosphorus status of sheep and dairy cattle and the composition of locally grown cereal grains and poultry feeding stuffs. Cereal hay investigations have related to factors governing the yield, nutritive value and losses in curing and storing. In certain of these investigations he has cooperated with others, notably Dr. J. F. Filmer, Mr. F. L. Shier and Dr. H. W. Bennetts.

For some years Professor Underwood has been actively associated with scientific organizations. He is a past President of the W.A. Branch of A.I.A.S. He has also been Chairman of the W.A. division of the Australian Association of Scientific Workers and is at present a member of the executive committee of the Australian National Research Council, a Fellow of the Australian and New Zealand Association for the Advancement of Science, Chairman of the Western Australian State Nutrition Committee, and a member of the Nutrition Committee of the National Health and Medical Research Council.

Professor Underwood for some years has been part-time lecturer in animal physiology and biochemistry at the University of W.A. and has directed the activities of honours students in these

fields. His experience in the field of agricultural education and research and his appreciation of the problems of the farmer should prove valuable aids to him in his new task, and will, no doubt, be reflected in future agricultural graduates from the University of W.A.

## The Executive of C.S.I.R.

The appointment of Dr. A. E. V. Richardson as Chief Executive Officer of the Council for Scientific and Industrial Research is notable news for members, and in offering its congratulations the Institute will wish Dr. Richardson every success in the heavy duties and responsibilities now falling to his lot. The appointment has been brought about by the retirement of Sir George Julius as Chairman and the elevation of the former Chief Executive Officer, Sir David Rivett, to the Chairmanship.

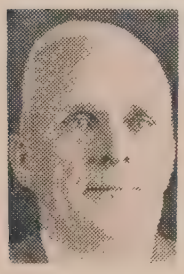
Dr. Richardson has been an active member of the Institute. Its first President, he continued to serve on the Council as proxy delegate for the South Australian Branch during the whole time the Council operated in Melbourne. His regular attendance and wise counsel were generally appreciated, particularly by the Branch he represented.

In 1926, soon after its present form of organization was instituted, Dr. Richardson accepted appointment as a part-time member of the C.S.I.R. Executive, and in this way ensured that research in agricultural matters would receive due attention in the new organization. Indeed, until World War II varied the complexion of the demand for scientific research, C.S.I.R. was mainly concerned with investigations connected with primary industry. The increasing attention being paid to the problems of rural industry eventually led to Dr. Richardson accepting full-time appointment with C.S.I.R. and compelled his relinquishing the post of Waite Professor of Agriculture and Director of the Waite Institute, University of Adelaide, a dual position which he was the first to occupy.

A further change in the constitution of the Executive : the appointment of Dr. Ian Clunies Ross, Dean of the Faculty of Veterinary Science in the University of Sydney as a full-time member will also be welcomed for the added strength it gives to this nationally important organization.

## Retirement of Mr. Ernest Breakwell.

Mr. Breakwell, who recently retired from his position with the New South Wales Department of Education, has been associated with the N.S.W. branch of the Australian Institute of Agricultural Science since its inception, serving as president in 1941.



He was born at Pelsall, Staffs., England, and attended the East Maitland Boys' High School. In 1900 he was appointed Pupil Teacher by the N.S.W. Department of Public Instruction, later attending the Sydney Training College and University.

Mr. Breakwell has a unique record of service in the N.S.W. Departments of Agriculture and Education. He was the first Science Teacher in the Department of Education (1908-12), first Agrostologist in the Department of Agriculture (1912-22), Principal of the Agricultural High School, Yanco (1922-28), the first organizer of the Junior Farmers' Clubs, and has been Inspector of Schools since 1932. While he was with the Department of Agriculture he was also Government Seed Tester and the compiler of the Pure Seeds Act. The introduction of Kikuyu and Elephant grasses into Australia was due to him.

He compiled the publications " Grasses and Fodder Plants of N.S.W." and " The Teachers' Nature Study Manual " and has written items for Chambers' Encyclopædia and papers published in the *Proceedings of the Linnean Society of N.S.W.*

The Junior Farmers' Club organization, which he inaugurated in October, 1928, has proved to be one of the greatest factors in the agricultural education of our rural youth. Considerable criticism had to be faced and many obstacles overcome in the early stages, but, as shown by the present enrolment of nearly 13,000 members, it has succeeded in giving the farm boy and girl a real and practical interest in the parents' farm, and in providing the country-town adolescent with horticultural and other interests in the home. In other words it has largely eliminated a previously existent desire to follow any calling rather than that of agriculture.

The practical nature of the projects, compiled by agricultural experts, has lead to a steady improvement in local agricultural practices. The parents and public have encouraged hundreds of these Junior Farmers to increase their agricultural knowledge by courses at agricultural high schools and colleges, by attendance at show camps, field days, and demonstrations, by educational tours, merit certificates, club leadership and many other means.

During the period the movement has been in existence, many of these Junior Farmers have become leading agricultural authorities in their districts It is a lasting tribute to Mr. Breakwell that many thousands of these rural youths have been trained to take their part in the future development of Australia's greatest industry.

## United Nations Relief and Rehabilitation Administration.

Two men who are widely known in agricultural circles in New South Wales are giving distinguished service to the United Nations Relief and Rehabilitation Administration in war-stricken areas.

They are Mr. Arthur G. Lowndes, formerly rural economist with the Bank of New South Wales, now Australian Liaison Officer to U.N.R.R.A.'s China office, and Mr. Walter H. Pawley, formerly senior economics research officer in the N.S.W. Department of Agriculture and lecturer in agricultural economics in Sydney University, now agricultural economist with U.N.R.R.A., at present in Manila. Both are graduates of Sydney University.

Mr. Lowndes returned to Australia last week after five eventful months in China. A major in the A.I.F. from 1940 until he joined U.N.R.R.A., he was for a time attached to the staff of Lieut.-General Northcott. He was the first foreign civilian to be received into Lin-i, Communist capital of Shantung province, when he led a truck convoy 200 miles to take the first U.N.R.R.A. supplies into that territory.

He inspected more than twenty Chinese woollen mills in Shanghai, Peiping and Tiensin, to find out the type of wool required to get them working again. He believes that a great future market exists for Australian wool in China.

Mr. Pawley is engaged on an agricultural survey of the Philippines. The rice crop will not be more than 60 per cent. of normal, and in fifteen areas starvation point has been reached.

Food, particularly rice, farm animals, housing and tools were the greatest shortages found by Mr. Pawley in devastated Luzon, the main island of the Philippines.

Lacking cotton thread for nets, fishermen are living in semi-subsistence conditions, he says. Often they unpick discarded army canvas to obtain twine for nets.

At Lamao, the largest citrus nursery in the Orient has been completely destroyed and cannot be regrown within twenty years.

Over large areas where fighting was severe housing and sanitation are primitive. Farm water buffalo have been killed and bull carts destroyed.

## Agricultural Policy in the Post-War Period.

Acting under the terms of a resolution of Council at its December meeting, the President has forwarded the following statement to the Prime Minister for consideration by his Government :

The seventh general meeting of the Australian Institute of Agricultural Science, held in Melbourne in February, 1945, after a discussion of " Agricultural Policy in the Post-war Period ", passed the following resolutions :

1. That this Institute recognizes that the agricultural production policies of the Commonwealth and State Departments should be coordinated in order to meet the needs of post-war agriculture.
2. That this Institute recognizes the need for an all-Australian agricultural policy and believes that this policy can best be achieved by a full-time and competently staffed Commonwealth organization which recognizes the State's responsibilities and rights as well as the Commonwealth's responsibilities, the latter being especially important in matters of overseas trade.
3. While recognizing that this must involve employment of trained technical officers by the Commonwealth, and while recognizing that the chief source of these officers is existing Commonwealth and State Departments, the Institute stresses the need for the release by existing Departments of suitable officers for this work.
4. That the Commonwealth Government be asked to arrange suitable conditions of employment, salaries and superannuation, including some means of transference of superannuation rights, to facilitate the transfer of officers to the Commonwealth Public Service from other Government Departments and Institutions.

In submitting these resolutions for the attention of the appropriate Commonwealth authorities, it is desired to append certain observations having reference to the background against which they were passed.

1. With regard to the general principle of the foregoing resolutions, the Institute wishes to draw attention to the fact that it is widely recognized by all concerned in agriculture that there is urgent need in the Commonwealth for a national over-all agricultural policy, and in this connection it recognizes certain facts,

(*a*) agriculture is by far the most important industry in the Commonwealth ;
(*b*) the future of agriculture in the Commonwealth and the prosperity of Australia as a whole, depend not only on the domestic consumption but, to a large extent, on overseas consumption of our agricultural products ;
(*c*) under existing constitutions certain powers relating to agriculture and marketing are possessed by the Commonwealth and others by the States ;
(*d*) to achieve an effective all-Australian Agricultural Policy, it is therefore essential that the agricultural policies of the Commonwealth and States be completely coordinated.

2. An effective all-Australian Agricultural Policy can only be laid down on the basis of an intensive study of the domestic agricultural requirements and the possible overseas markets for our products. This study must be continuous and should be planned so as to provide the Governmental authorities with advice on such matters as :

(1) the implementation of Commonwealth obligations towards the United Nations Organizations ;
(2) the expansion or curtailment, as found necessary, of existing rural industries and the establishment of new ones ;
(3) the adoption of uniform standards for all agricultural products throughout the Commonwealth ;
(4) the coordination of all major agricultural research programmes,

and all technical and administrative considerations pertaining to those and other national rural problems.

In order to implement such a programme, there is clear need, in addition to the State Departments of Agriculture, for an effective Commonwealth organization which, in view of the technical nature of its functions, must be staffed with highly trained agricultural personnel.

3. The activities of the Commonwealth in the field of agriculture, intensified by the exigencies of war and often improvised to meet emergent and ever-changing situations, are in clear need of rationalization. The simple fact that the various phases of the work come under the control of so many different departments and sub-departments clearly indicates the need for reorganization.

Agriculture being of such importance to the Commonwealth, it would seem desirable that it be controlled by a separate Ministry and Department which would, apart from its major responsibility in formulating an overall national policy, take over from other Commonwealth agencies all activities coming within its terms of reference. If, however, for administrative reasons it is not deemed fitting at the present time to establish a separate ministry, then it is regarded by the Institute as imperative that the status and functions of the Agricultural Department should not be subordinated to those of the other department with which it is associated.

4. As already indicated, it will be in the interests of operational and administrative efficiency for all Commonwealth officers engaged in agricultural work to be grouped into one cohesive unit. Since such officers must, for the greater part, be drawn from existing technical departments, it is suggested that agreement should be sought between all agencies involved so that the necessary transfers of staff can be equitably arranged between the States and the Commonwealth. In such agreement, the Institute deems it proper, as indicated in resolution No. 4, that due attention should be given to the general conditions of employment in the various agricultural services and, especially, to the provision of machinery whereby officers transferring would not be prejudiced in respect to any existing superannuation, seniority or other rights.

## Trends in Tasmanian Agriculture.

In his presidential address to the Tasmanian Branch, Mr. F. W. Hicks spoke on trends in post-war agriculture in that State. Tasmania was allocated a very large acreage of cash crop production for Commonwealth war-time requirements : up to 130,000 acres in the peak year. This figure represents about half of the total arable area (fruit crops excepted) of the State. In the general swing to cash cropping (potatoes, vegetables, blue peas) the agricultural balance was, of course, seriously upset and severe declines occurred in the dairying and pig industries. The newly established fat lamb industry also suffered a severe check. Poultry, on the other hand, expanded very rapidly and, as this also occurred in mainland States, the Commonwealth will be faced with the serious problem of disposing of a possible surplus of over 60,000,000 dozen eggs.

Efforts have now to be directed towards regaining the normal economic balance between stock and crop by expanding such industries as dairying, on which so much of the primary wealth of the State depends. Mr. Hicks pointed out that over 100,000 acres of land are under review for rehabilitation and settlement of servicemen. The establishment of several hundred farms for dairying and other activities is envisaged within the next few years. Much of this land is undeveloped and the projects will involve a great deal of work in provision of fencing, transport, educational and other facilities.

## Infertility in Sheep.

In a recent address to the Western Australian Branch, Dr. E. J. Underwood said that during the last few years conditions of infertility, dystocia and prolapse had become common in areas where the pastures were dominated by early Dwalganup subterranean clover. The problem appeared to have started about 1940 or a little earlier, and it became evident from field data that merinos were more susceptible to the infertility than crossbreds. The prolapse occurs to the extent of about 1 per cent. some months after lambing, independent of breed.

The area affected stretches from Mount Barker to New Norcia, and Geraldton. The only other definite area is on Kangaroo Island and some indication on Yorke Peninsula in South Australia. South of Perth the main areas are on white gum soils, but north of Perth the trouble

occurs, also on York gum soils. There is little or no relation to the time the pasture has been established, and there are some farms with plenty of early subterranean clover not yet showing the trouble.

The infertile ewes have normal œstrus but do not conceive, and in several cases where ova have been recovered no segmentation has been found. On the pathological side in nearly all cases of infertility, dystocia and prolapse studied, a cystic condition of the endometrium has been found.

A study of the sex hormone picture of the merino, about which very little was known, has revealed that in normal pregnant ewes little or no gonadotrophin is excreted, but small amounts of œstrogen are excreted in the last few weeks of pregnancy. Some preliminary tests on non-pregnant ewes and on a wether grazing on subterranean clover, have shown the presence of œstrogenic material in the urine. There is no evidence that cattle are affected. Guinea-pigs have been shown experimentally to be susceptible to cystic endometrium in laboratories in other parts of the world. This condition has been developed on subterranean clover in three weeks and would discount any direct deficiency hypothesis. Recent findings on hormones and with guinea-pigs should prove valuable in solving this problem.

# Book Reviews

## FARMING AND GARDENING FOR HEALTH OR DISEASE, by Sir Albert Howard.

(*Faber and Faber Ltd., London*, 1945. *Price* 12*s.* 6*d. sterling.*)

Sir Albert Howard's latest book is delightfully provocative and is a fitting sequel to his "Agricultural Testament" (Oxford Press, 1940).

His primary thesis is that all disease is basically a matter of wrong nutrition, and to Sir Albert this mostly means the use of artificial fertilizers and failure to provide adequate quantities of humus in the form of Indore compost.

He admits the essential features of orthodox mineral nutrition, but deplores the N.P.K. mentality and the over-emphasis laid on the inorganic as opposed to the organic nutrition of plants.

His concept of organic nutrition is based on the almost universal occurrence of mycorrhiza in soils properly supplied with humus, and it will certainly surprise most agriculturists to know that mycorrhiza has been demonstrated in the wide variety of cultivated crops quoted by Sir Albert. He considers the main purpose of mycorrhiza to be the maintenance of proper nitrogen nutrition and that the fungous mycelium supplies the root cells with proteins derived from organic nitrogen in humus.

An integral part of the concept is that mycorrhizal association only occurs in the presence of abundant organic matter, and if this is lacking disease will develop due to inadequate protein.

Common crops in which mycorrhiza has never been detected include tomatoes and certain crucifers, but as such plants all respond equally well to the elixir of humus, they are considered to obtain their organic nitrogen by direct absorption from decomposed bacterial cells.

Humus also extends its benefit to both livestock and humans and when fed on properly grown foodstuffs there is a marked improvement in health and in many cases an immunity to disease is conferred. For example, cattle are rendered immune to both foot and mouth disease and contagious abortion even when they have direct contact with other infected animals.

The evidence for immunity to human diseases, however, is not so clear-cut.

Despite a great deal of material with which the modern worker will disagree, Sir Albert Howard's book contains much which warrants careful consideration. It contains several excellent criticisms of modern agricultural research and many of his observations concerning departmentalism and sectionalization are particularly appropriate to Australian research institutions.

His trenchant criticism of the classical Rothamsted experiments will be heresy to the faithful.

His scorn for the statistician will anger the biometrically inclined.

His heartless definition of the plant pathologist as a "laboratory hermit, a specialist of specialists, intent on learning more and more about less and less" is a literary gem that should cause many a worker to pause and reflect.

The book is singularly free from typographical errors; it is extremely well written and the style is lucid and fluent.

It should be read by all interested in agricultural research, and although it predicates the elimination of the pathologist it is none the less enjoyable.

E. T. Edwards.

## THE ESTABLISHMENT AND EARLY MANAGEMENT OF SOWN PASTURES.

(Bull. 34, *Imperial Bureau of Pastures and Forage Crops, in collaboration with others. Price* 7*s. sterling.*)

This bulletin provides a symposium of contributions from Great Britain, Canada, Australia, New Zealand and the United States. It is a good example of the effectiveness with which a coordinated picture can be given of the subject as it appears in different parts of the world.

The discussions of environment, methods of establishment, seeds mixtures in use or recommended, their functions and their early management, provide a basic fund of information that is likely to be useful to workers in agronomy and allied fields generally. The inclusion of 93 photographs is especially to be commended. They demonstrate to the reader the types of pasture or country described in each paper ; and their wise choice and extensive use in this case are a feature of the bulletin.

Material from outside Great Britain has been collected by the accepted procedure of working through an official correspondent in each overseas country. The method followed in the United States contrasts favourably with that adopted in Australia. The United States has been subdivided into seven natural regions for each of which a local authority has been asked to contribute. The correspondent for Australia, however, has apparently found it unnecessary to go further than two of his own staff at Canberra, although the terrain covered is equivalent in size to the United States. A good view has been given of Australian pastures, but not of Australian work relating to the title, much of which has been disregarded.

The contributions throughout the bulletin are set ecologically, with references to prevailing conditions of climate, limiting soil factors, the species and strains of herbage plants employed, their incorporation in suitable mixtures, and the factors concerned in early management.

The grass-legume association is generally accepted as a basic unit of pastures ; there is some appreciation of mineral deficiencies which, however, in many places have obviously not been fully investigated along the lines now known to be necessary. The importance of pastures in soil conservation and soil building is emphasized ; and the grassland association is also seen as an avenue of production, pivotal to the cropping system employed, and entitled to receive at least as much attention as other crops. Increasing stress has been laid upon the value of the temporary ley.

The thirteen articles naturally vary in quality and the principal weaknesses, from a scientific angle, are those of prolixity and empiricism with, unfortunately, scant bibliographical references in most but not all cases. There is some repetition ; but such is quite unavoidable and is not necessarily a disadvantage in such a compilation. It would be an interesting task to sort out, in terms of principle, the scientific threads of reason and logic that bind the factual matter together, and define the avenues of basic research that could be followed with profit to practical grassland development in the future.

H. C. Trumble.

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# Personal Notes

A large number of members have been discharged from the various services and are resuming former duties :—Drs. W. V. Ludbrook and P. Calvert and Mr. F. N. Ratcliffe (A.C.T.) ; Messrs. S. L. Allman, T. Atkinson, R. N. McCullock (N.S.W.) ; Messrs. J. E. C. Aberdeen, R. F. Langdon, L. F. Mandelson and J. H. Simmonds (Q.) ; Messrs. E. J. Johnston, D. C. Swan and A. J. K. Walker (S.A.) ; Messrs. J. G. Baldwin, M. J. Cannon, A. G. Goudie and P. F. Marriott (Vic.).

Messrs. J. Bull and H. Smith, who were prisoners of war in Malaya, have returned to Australia. Mr. Bull was appointed an Agricultural Rehabilitation Officer in China and spent three months in the south-west Pacific area. He has resigned for domestic reasons. Mr. Smith was a foundation member of the A.C.T. Branch, but resigned to take up a position in the Rubber Research Institute of Malaya. He is recuperating in Canberra.

Professor H. C. Trumble is a delegate in the Scientific Mission to Great Britain. Representing Plant Sciences and Agriculture, he will attend a series of conferences convened for June-July by the Royal Society of London, the Department of Scientific and Industrial Research and the Executive Council of the Imperial Agricultural Bureaux.

Mr. A. V. Hill is going to the U.S.A. to spend some months in studying problems of the tobacco industry.

Professor Eric Ashby returned to Sydney in January after a year spent as Scientific Attaché to the Australian Legation in Moscow. He has accepted appointment to the Chair of Botany and Director of Research in Botany at the University of Manchester. He expects to take up his new duties in 1947.

Mr. E. B. Rice, Director of Dairying in Queensland, investigated dairying methods in New Zealand recently.

Mr. D. O. Atherton has been appointed Deputy Co-ordinator of Rural Training in Queensland. Mr. N. Davenport has accepted a similar position in Western Australia.

Mr. J. L. Provan, who has been Principal of the School of Primary Agriculture at Burnley, has been appointed Principal of Dookie Agricultural College.

Mr. N. H. White, formerly Plant Pathologist in the Tasmanian Department of Agriculture, has joined the staff of the Sydney University as a lecturer in the School of Agriculture. Mr. White was recently admitted to the degree of D.Sc. by the University of Tasmania. His thesis, which comprised a series of papers on the physiology and genetics of the fungus *Ophiobolus graminis*, on the Takeall disease of cereals, on the development of the fungus *Mutinus* and on virus disease in potatoes, earned very favourable comments from his overseas examiners, Professor F. M. Brooks and Mr. S. D. Garrett.

Dr. I. Mackerras, since his discharge from the Army, has gone to Brisbane to take charge of the section of Veterinary Entomology, established in that city as part of the Division of Economic Entomology, C.S.I.R.

An interesting note has been received from Mr. F. H. Hooper, who is now associated with H. W. Carter & Co., Bristol, England. He is " working in a laboratory associated with the production of fruit juices, syrups and powders, all containing ascorbic acid ". He sighs for a few bananas and pineapples, peaches and apricots.

Mr. A. T. Pugsley has been appointed Plant Geneticist at the Waite Institute ; his predecessor, Dr. I. F. Phipps, has been touring New Zealand on behalf of I.C.I.A.N.Z., with which company he is now associated.

Mr. A. H. E. McDonald, Chief of the Division of Plant Industry, N.S.W. Department of Agriculture, has retired after twenty-nine and a half years' service. Mr. A. W. S. Moodie, formerly Senior Agrostologist and a past President of the N.S.W. Branch, succeeds Mr. McDonald.

Mr. L. C. Birch, of the Entomology Department, Waite Institute, was awarded a C.S.I.R. Senior Research Studentship and has left for the U.S.A. He will work at the University of Chicago with Dr. T. Park, who has specialized in the study of population growth.

Mr. T. H. Strong has been seconded from the Division of Soils, C.S.I.R., to the Ministry of Post-War Reconstruction to undertake land settlement investigations.

Mr. C. R. Millikan has been promoted to the position of Senior Plant Pathologist at the Plant Research Laboratory, Burnley, Victoria.

Mr. H. J. Sims, formerly Manager of the Mallee Research Station, Walpeup, has been appointed Cerealist in the Victorian Department of Agriculture.

Mr. A. B. Cashmore has been appointed to the Allied Control Commission in Germany, where he has taken up duty.

Mr. B. E. Butler, Division of Soils, C.S.I.R., has been placed in charge of soil surveys of the irrigated areas of N.S.W. and Victoria. He is stationed at Deniliquin.

Mr. F. O. Grogan has been admitted to the degree of M.Sc. (Agriculture) in the University of Western Australia. His thesis included papers on agricultural economics and covered research into the costs of wheat growing in the west. Mr. Grogan is attached to the Department of Commerce in Perth.

Miss J. A. Demaine has resigned her position in the Seed Testing Laboratory of the Victorian Department of Agriculture to become a technical officer at the Irrigation Research Station, Griffith, N.S.W.

Mr. J. L. Schofield has resigned from the Queensland Department of Agriculture and gone to England.

Mr. J. F. Kennedy has left the Bureau of Investigation, Queensland Department of Public Lands, to become officer-in-charge of the National Field Station at Cunnamulla.

Mr. R. H. Hayman has resigned as Acting Manager of State Experiment Farm, Rutherglen, to become Research Officer and Farm Manager at the McMaster Field Station, Liverpool, N.S.W.

Mr. E. G. Hall has resigned from the Division of Horticulture, N.S.W., Department of Agriculture, to take up an appointment as research officer at the Homebush Food Preservation Laboratory and will work on problems of plant physiology.

Capt. A. C. Sundstrom, on discharge from the Army, and Mr. K. G. Carn have joined the staff of Messrs. Buzacott-Wolseley Pty. Capt. Sundstrom had charge of army farms in New Guinea.

Mr. J. R. Sutherland has resigned from the Education Department to accept an appointment with the N.S.W. Department of Agriculture.